

THE BROWN HEMATITE ORE BANKS OF SPRUCE CREEK, WARRIOR'S MARK RUN, AND HALF MOON RUN, IN HUNTINGDON AND CENTRE COUNTIES, PENNSYLVANIA, ALONG THE LINE OF THE LEWISBURG, CENTRE COUNTY AND TYRONE RAILROAD.

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PRELIMINARY CHAPTER.

The district under examination, with an area of about one hundred square miles, is bounded on the west by the Bald Eagle Mountain, on the east by Tussey Mountain, and on the south by the Little Juniata River, and the Pennsylvania Central Railroad.

The Huntingdon-Centre County-line crosses it transversely from mountain to mountain. The Huntingdon-Blair County-line follows the river.

Spruce Creek flows southward along the foot of Tussey Mountain. Its branches, Warrior's Mark Run and Half Moon Run, cross the country from Bald Eagle Mountain, along the foot of which their head waters flow. Logan's Run flows at the foot of Bald Eagle Mountain into the Little Juniata River near Tyrone. See large Map.

The river and the two runs afford fine opportunities for three cross-sections, represented in figs. 1, 2 and 3. These sections have been photolithographed (like the map) to a very reduced scale for convenience of publication, but were carefully constructed on the same vertical and horizontal large scale, so that their geology may be relied on.

The map was plotted with great care from the survey notes of Mr. Franklin Platt,* (as were also all the reduced local maps of the Ore Banks, figs. 8 to 44) and adjusted with almost no variation to the railroad survey maps in the office of that experienced and most reliable Civil Engineer, Mr. Lenffer, who located, constructed and has in charge the completion of the L. C. C. and T. R. R., to whose courtesy I am in this as in other cases, so largely and gladly indebted.

The map is drawn in ten foot contour lines, determined by aneroid observations, based on the spirit levels of the railway lines, preliminary and adopted. One set of aneroid observations was carried to the top of Tussey from Pennsylvania Furnace; the rest of the mountain being drawn in by rough trigonometrical observations from the Spruce Creek road. The gaps in its terrace are all properly placed and their characteristic features given: but slight variations in the almost dead level crest of the mountain could only be indicated. The survey of the Spruce Creek Valley was made rapidly and only for the purpose of assigning a proper value to its topographical features, a new township survey by a corps of odometer surveyors being the basis. Here a considerable adjustment had to be made, which renders this part of the map of no authority, as against

*Formerly an Assistant on the U. S. Coast Survey.

careful future surveys. The adjustment affects the whole southeast corner of the map, viz.: the interval between the mouth of Warrior's Run and the river. It is none of it accurate. The rest of the map is very accurate and reliable.

Various former surveys of the Juniata were compared in plotting Mr. Platt's survey along the Pennsylvania Railroad, and all were found to be discordant in details, but the topographical features of the deeply eroded bed of the Little Juniata are portrayed with sufficient precision.

Time failed for a careful survey of the mouths of Canoe and Sinking Valleys south of the river. I leave these and the interesting synclinal mountain (Canoe Mountain) which separates them, for a future opportunity. Canoe Valley leads south into Morrison's Cove, a reconnaissance survey of which I made some years ago for the Pennsylvania R. R. Co., to determine the economical value and geological attitude of its brown hematite iron ores, the analogues of those to be described in this report.

Three sets of aneroid levels were carried to the top of the Bald Eagle Mountain, and two of these were continued to its western base, along which flows the Big and Little Bald Eagle Creeks, and runs the Bald Eagle (Tyrone, Bellefonte and Lockhaven) Railroad. A much more careful study of Bald Eagle Mountain than of Tussey Mountain had to be made; first, on account of the Great (Bellefonte or Tyrone Forge) Fault which runs along its east foot; secondly, on account of the vertical attitude of its rocks and the very irregular erosion to which it has therefore yielded; thirdly, on account of a deflection of trend, due to the little synclinal crimple shown in two of the Cross Sections; and fourthly, on account of the outcrops of fossil ore on its western slope. Yet, I should be glad to make a complete hypsometric projection of this very interesting mountain, with its dentated double crest, for scientific purposes. Its character is, however, well portrayed in my map and will tell the whole story to any geologist.

A second map (also reduced by photolithography from its original scale of 100 perches to the inch,) is appended to this report. It is a copy, corrected to date, of the land line map* of Lyon, Shorb & Co.'s ore and other lands in Huntingdon, Blair and Centre Counties, covering about 200,000 acres in the valley and on its two bounding mountains, and stretching westward beyond the Bald Eagle Creek to the coal measures on the crest of the Alleghany Mountain. It was impossible to transfer the numerous and complicated land lines of this map to my topographical map without concealing its features beneath a net work of irrelevant indications. I have gone even farther in my anxiety to show with unobstructed clearness the geology by the topography; I have abstained from introducing *local names* upon my map, trusting to the intelligence of those who consult it, guided by a small key map in its southeast corner, and by the descriptions I give of localities with reference to the numerous ore banks which are *numbered*. The key to the numbers will be found in the northeast corner

* The original is in the office of Mr. Lowrie, at Warrior's Creek, Huntingdon Co., Pa.

of the map. The numbers follow rudely the ore belts, but not on any strictly scientific principle; they are arranged for the convenience of the reader.

A third map, heliotyped from a large original study of Brush Mountain (Bald Eagle Mountain continued southward across the Little Juniata River) is also appended, to show the outcrop of the Fossil Ore on that part of the property which extends in that direction. But the description of these Upper Silurian Fossil Ores must be kept separate from my discussion of the Lower Silurian Brown Hematites, or Limonites of the Nittany Valley.

GENERAL GEOLOGICAL CONSIDERATIONS.

The country specially examined in this report covers outcrops of the following geological formations, designated by the numbers of the old Pennsylvania State Survey, and the names given them by English and by New York Geologists.

No. V.	Upper Silurian.	{ Clinton Red Shale.
No. IV.	{ Upper, white. Middle, red, Lower, grey.	{ Medina Sandstone. Oneida Conglomerate.
No. III.	Lower Silurian.	{ Hudson River Slate.
No. II.	Lower Silurian.	{ Trenton Limestone. Black River Limestone. Birdseye Limestone. Chazy Limestone. Calciferous Sandstone.
No. I.	Lower Silurian.	{ Potsdam Sandstone.

The Iron ore horizons described in this report are as follows:

In No. V. The upper or soft fossil ores.

The lower or hard fossil ore.

In No. II. The first horizon at the bottom of the Trenton Limestone: Pennsylvania Furnace and Spruce Creek ores, and ores of Cale Hollow.

In No. II. The second horizon: the whole Dry Hollow Range of ore banks, including Huntingdon Furnace and Dorsey Bank.

In No. II. The lowest horizon, far above the top of the Calciferous: the Warrior's Mark and Lovetown Range and the Pennington Range.

The dip of the rock, of the whole country exhibited on the map, from the foot of Bald Eagle Mountain to the crest of Tussey, is towards the S. S. E., with one or two undulations of no great moment. This is plainly shown by the three cross sections, figs. 1, 2, 3.

A great fault runs along the foot of Bald Eagle Mountain, and on the west side of this fault the same formations are seen descending vertically. They then curve sharply, and pass horizontally N. Northwestward under the Alleghany Mountains, as shown in diagram section fig. 4.

This diagram section is constructed from the dips of the Upper Silurian, Devonian and Coal Measure rocks, observed on a survey of the road from Bald Eagle Furnace up Emigh's run and Laurel Creek to the crest of the Alleghany Mountain. The measurement of the curves of the different layers of this upturned mass, taken at every thousand feet, as shown in the diagram, result in giving a slope of 50° to 54° to the bassett edges of the broken mass.

It is evident that the upslide of the other section of the broken mass has conformed to this slope, and that the uniform dip of $54^{\circ} \pm$ observable for miles along the S. S. East foot of Bald Eagle Mountain (as represented in Juniata Section, and Sections AB and CD) is perfectly explained by the diagram.

This is the first time, I believe, a solution of this difficult problem in structural geology has been reached; and its bearings upon similar phenomena attending upthrow-faults and broken anticlinals in other regions will be noticed by geologists.

The theoretical deductions from this solution are important.

It proves that the original fault was in a vertical plane, and not on a slant.

It proves that the lower Silurian Limestone mass has ridden upon this slope to a considerable height, probably several miles, in the air above the present surface.

It illustrates the great erosion of the country, amounting to *thousands of cubic miles* of earth crust, including the coal measures (which are preserved on Broad Top, 20 miles to the southeast,) and gives us the source of the Cretaceous and Tertiary deposits of New Jersey and Delaware.

It leads me even to suspect the existence of a subterranean range of Laurentian Mountains (with their usual magnetic iron ores) at the bottom of the fault; this range determining the line of fracture.

It accounts for the general S. S. E. dip across the whole valley, Tussey Mountain, and as far as Huntingdon.

It assures us that the brown hematite ore beds of the district studied in this report belong to rocks of different ages, and are ranged in parallel belts according as the formations which carry them descend successively (S. S. Eastward,) beneath the present surface.

It confirms the opinion that the quantity of ore in these belts is not a local accident at each of the ore banks, but bears a fixed relation and proportion to the outcrop run of the ore-bearing limestones, lengthwise of the valley; and, therefore, that any estimate of the quantity of ore we may make by examining the diggings, must fall short of the actual quantity of ore to be mined in future years in this valley.

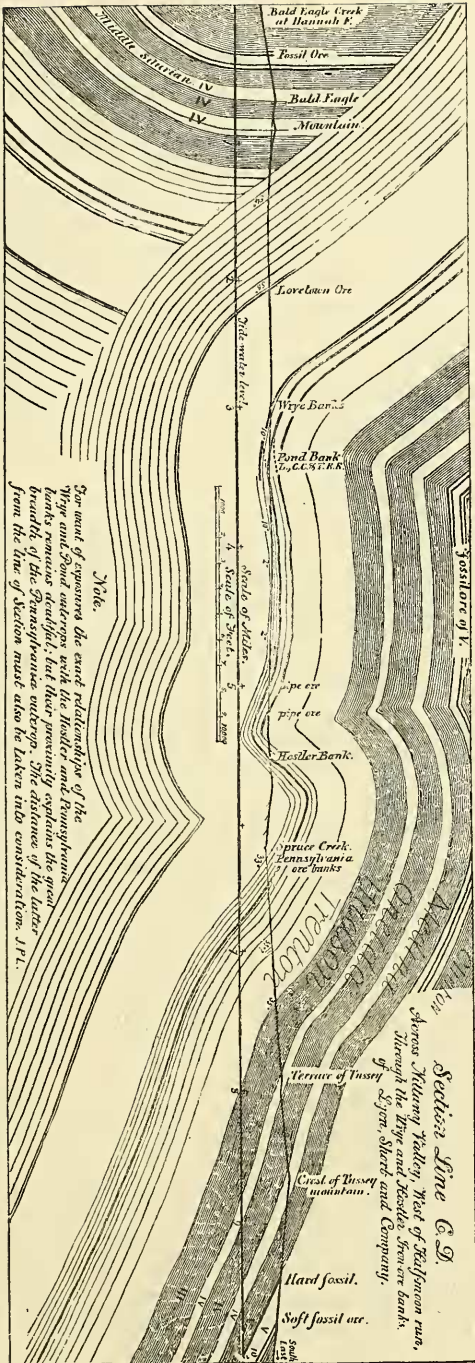


FIG. 3.

Note.
 Same amount of exposure the exact relationship of the
 Wye and Pond water level with the Hosler and
 Pond banks remains doubtful, but their proximity explains the great
 breadth of the Pennsylvania outcrop. The distance of the latter
 from the line of Section must also be taken into consideration. 1871.

Section of Tussy
 across Tully's Valley, West of Jefferson run,
 through the Wye and Hosler iron ore banks,
 of Tully, Sherrill and Company.

Hard fossil.
 Soft fossil ore.

The *original source* of the brown hematite iron ores of our Lower Silurian limestone valleys has been speculatively sought for without sufficient investigation in the field; and much practical mischief has resulted from the errors promulgated. Most persons have looked upon them as accidental and local inwashes from unknown sites. Some have more systematically defined them as a residual precipitate from the disseminated iron-sand grains of the surrounding Middle Silurian mountain rocks during their erosion.

All such vague speculations might have been avoided had the results of Dr. R. M. S. Jackson's survey of the Nittany Valley ore beds in 1838 or 1839 been published by himself. As assistant on the geological survey of Pennsylvania he obtained the data necessary for concluding, at that early day, that they were deposits *in loco originali*, of the iron (as hydrated peroxide) set free from the limestone or dolomite rocks during their gradual erosion and dissolution.

I have myself, during the last twenty years, had ample opportunities for arriving independently at the same conclusion; and an intelligent study and comparison of the aspects of the ores and rocks in our iron ore banks will, I think, satisfy any good geologist in the same sense.

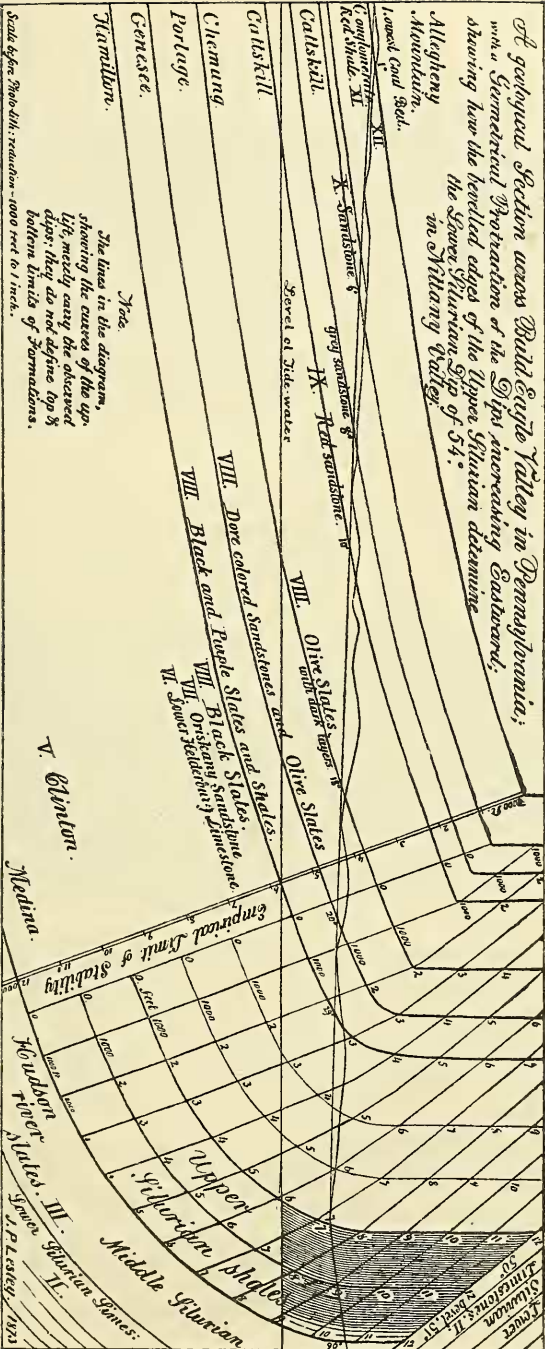
The precise *modus operandi* of the process is not yet well understood; for it involves chemical considerations not thoroughly worked out. But a general statement of the operation can be made without risk of serious error.

The rocks of the Lower Silurian Age were originally sea-muds, composed of rounded grains of dolomite (derived from previously existing Laurentian Land), cemented together with a paste of carbonate of lime. Some of the beds consisted also of rounded grains of quartz. Some of the layers were nearly pure carbonate of lime. All contained a larger or smaller percentage of iron, lead, zinc and other metals, precipitated either chemically, or by the agency of organic beings, from the solutions of their carbonates, chlorides, &c., in the river-and sea-waters. The orderly explanation of all the chemical and organic features of this complicated operation is still to be given to the scientific world. But all will agree that the general character of the calcareo-ferruginous muds, the sediments of that early geological age must have been much as above described.

During the long Upper Silurian, Devonian and Carbiniferous Ages, these Lower Silurian sediments were buried to a depth of over 16,000 feet, beneath the later sediments. They remained wet. Their great depth raised their temperature $16,000 \div 50 = 320^{\circ}$ Farenheit's thermometer; which added to the mean temperature of the surface, would keep them under the influence of a moist heat of nearly 400° F. through what to man is a small eternity of time.

Dr. Genth's discovery of the amorphous or gelatinous condition of a part of their silica is thus explainable. Varied reactions must have ensued. The carbonates of lime and magnesia combined as dolomites,

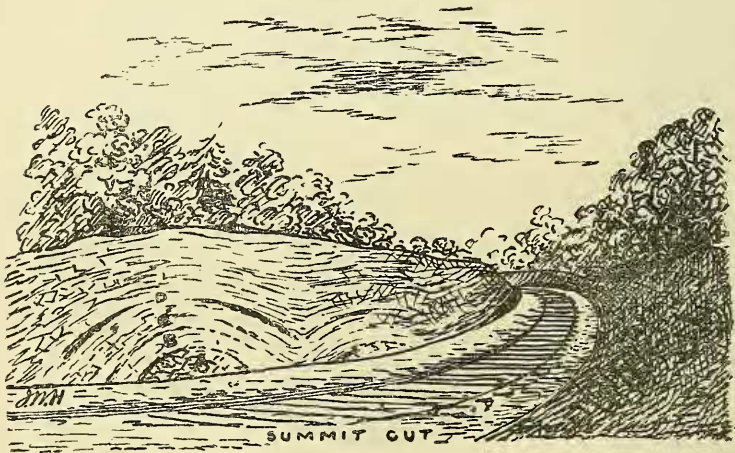
FIG. 4.



which in part crystallized in rhombohedral crystals, the forms of which we now see, in the outcrops, emptied by dissolution. The silica hardened (without crystallizing) around these rhombs, so that we see the same cavities in it. The iron became peroxydised as *fibrous* hematite and the silica can be obtained by dilute nitric acid also *in the same fibrous form*. All this points to the first formation of the iron ore while the rocks were still at a great depth, wet and soft and warm.

But at the end of the coal era the Middle States rose from the waves and have never been covered by the ocean since that time. The edges of the Bellefonte Fault stood as a mountain range as high as the Alps (see Fig. 4), and the backs of some of the great anticlinals of Pennsylvania must have formed plateaus then as high as Thibet and Bootan are now.

FIG. 5.



Erosion commenced and has continued through the Permian, Jurassic, Cretaceous and Tertiary Ages to the present day, and still goes on. The high plateau was gradually worn down to the present surface. Mountains once 30,000 or 40,000 feet high are now but 2,000 or 3,000 above sea level. The valleys were excavated as the mountains lowered, and the outcrops of the Lower Silurian limestones of Nittany Valley are but 800 to 1300 feet above tide (see the contour lines of the map).

This slow erosion gives us the second part of our explanation of the brown hematite iron ores. It explains the innumerable caverns and sink holes and dry hollows of this Nittany and other limestone valleys. It leads us to expect to find traces of such caverns and widened fissures and sink holes of the last preceding age, filled up with a wash of clay, sand, and iron ore from outcrops lately existing not far above the outcrops which run along the present surface.

The erosion now still going on, and the special activity of the last

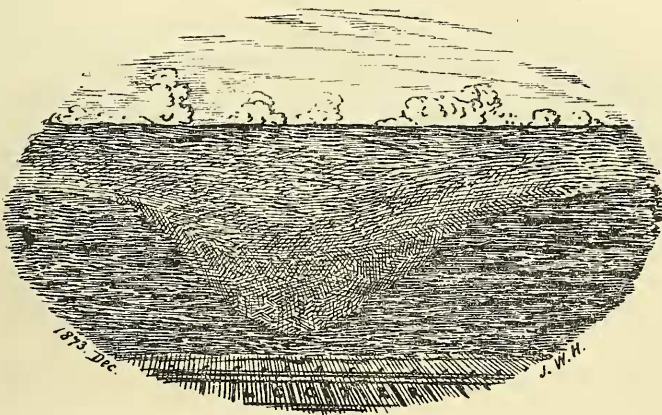
or glacial age, may very well explain that outspread of surface wash-ore which makes so large a feature of the case. It may also explain the corrugations of the clay and ore strata in these superficial wash-ore deposits as represented in Figures 5, 6, 7; the localities pictured being on the line of the railroad near the East Pennington Ore Banks.

Thus the different theories in vogue among our iron men are harmonised. Each theory has its own basis of truth, its own set of facts, but does not embrace all the phenomena.

Those who contend that the brown hematites lie in pockets are correct; but they must confine the assertion to that part of the ore which now occupies former caverns and fissures and sink-holes.

Those who contend that the brown hematites are surface washes caught by the accidental variations of the earth's surface, are correct; but they

FIG. 6.



Summit Cut, in siena-colored Wash-Ore, exhibiting erosion (?) & debris of pulverized Calcif: S.S.

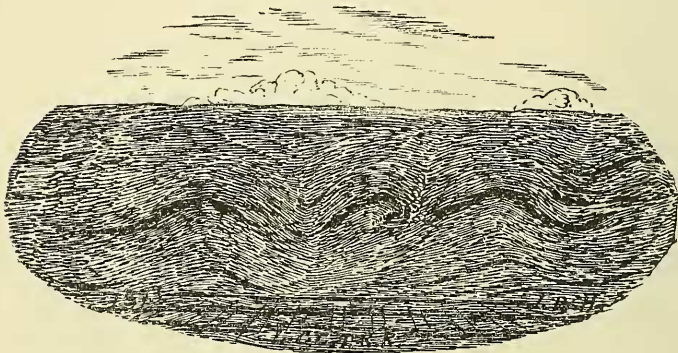
must limit the application of their theory to banks which show rolled gravel and rolled ore, and a confused and mingled mass of ore and sand and clay.

A third view is equally correct and much more important. It must be accepted as probable, that in spite of later movements, and in addition to cavern-deposit ores, and surface-wash ores, there are interstratified beds of brown hematite, still in their original places, although not in their original condition, descending with the general slope of the formations between undissolved limestone, dolomite and sandstone rocks to undetermined depths, and ranging lengthwise of the district, so that rows of ore-banks can be and have been opened in continuous belts of

many miles length, and on continuous outcrops of ore ground of every conceivable variety of character, quality and quantity.

It is provable by reference to sections Figures 1, 2, 3, and other illustrative drawings in this report, that there exists several of these belts; representing different *geological horizons*; and due to an extra charge of iron given, we know not how, to sediments of different ages. As, on a grand scale iron-bearing rocks occur at various stages of the column of palæozoic rocks from No. I, Potsdam S. S., to No. XII, Coal Measures,—so, within the narrower limits of one subdivision of this column, viz., in the Lower Silurian system, iron bearing rocks occur at various stages, separated by from 500 to 2000 feet. These have already been stated.

FIG. 7.



Summit Cut in Washore with Ore-streaks One foot thick.

The measurements will be given in my Detailed Description of the Ore Banks, and no repetition of them is here necessary.* I will only give in tabular form the thickness of the Lower Silurian Limestone formation so far as visible and as measured along Warrior's Mark Run :—

Hudson River Slates.....	feet.
Trenton Limestone, &c.....	2500
Pennsylvania Furnace and Cale Hollow Ore Banks :	
Interval of Limestones.....	700
Huntingdon Furnace Ore Banks :	
Interval of Limestones.....	550
Pipe-ore Range near Toll-gate :	
Interval of Limestones.....	1500
Pennington, Town, Lovetown Banks :	
Interval of Limestones.....	3000
The edge of the Fault stops further measurement downwards : .	
Total visible thickness of Limestones.....	7750

* See No. 31, Huntingdon Furnace Banks.

PRACTICAL VALUE OF THE ORES.

The experience of sixty years has demonstrated the exact values of the brown hematite iron ores of all the Lower Silurian Valleys of Pennsylvania : on the Lehigh ; in the Great or Cumberland Valley ; in Kishicoquillis Valley ; in Morrison's Cove, Canoe and Nittany Valleys.

The general resemblance of ores from all the Banks is striking. The local variations are still more striking. The key to those variations was only got when the true geological theory of structure was studied out. But it is still a perplexing question why red-short, cold-short and neutral ores should lie so near each other. There is scarcely an ore bank in Pennsylvania in which the chemist will not find some infusion of sulphur and phosphorus. But some ores have been so slightly charged with one or other, or both of these elements, that they rank in the first class.

Others are so heavily charged, that they are useless for Bessemer work ; take a low rank as anthracite or coke iron ores ; and only make good pig-metal when smelted in small quantities, with charcoal and a feeble cold-blast.

This is especially true of those of the lowest geological horizon or oldest in age, belonging to rocks of Pitsdam age, rocks which rise upon the flanks of the South Mountain. Fortunately, these ores nowhere reach the surface in Nittany Valley, being buried in the jaws of the Bellefonte Fault. Even the Pennington horizon is too high for these ores.

The consequence is, that most of the ores of the district under notice here yield a practically neutral ore and make the best possible iron in cold blast charcoal furnaces, and good iron with the hot blast, and mineral fuel. The appended analyses of Dr. Genth will make this fact evident.

Phosphorus, however, is found in all known Silurian Brown Hematite ores (with some rare exceptions) in quantity enough to prevent the manufacture of steel. But in some cases mixture with other ores will rectify the ore. In other respects the per centage of phosphorus is too small to do hurt. Dr. Genth's analyses will give the figures in this case also.

The reputation of Pennsylvania iron was greatly made at Pennsylvania Furnace. Its quality could not be surpassed. Neither the older Swedish, nor the best English, when English iron was still good, nor the more recent magnetite pig-metal of Lake Champlain and Missouri, have excelled it ; and it shared this reputation with furnaces smelting similar ores.

There are parts of the deposit in almost every Bank, which are sandy and lean. These have been hitherto fastidiously rejected by the charcoal coal blast furnaces of the district. Such ores are, however, in demand for our anthracite and coke furnaces, and the ever-increasing market for them will require the mining of the whole. I believe that carefully selected ore from these banks will even furnish iron fit for Bessemer use.

PROBABLE QUANTITY OF ORE.

Estimates of the quantity of Brown Hematite Ores are among the most uncertain of all earthly things. Hence I give special statements of the size of excavation and prisms of ore ground in sight for each of the ore banks, in the chapter of this Report devoted to their local description.

The surface ore wash is of various depths from 1 to 30 feet. The breadth of surface covered is sometimes but a few yards; sometimes several hundred yards. Intervals occur where all traces of surface ore vanish from the belt.

The thickness of the underlying clays varies from a few feet to a hundred and more. Sometimes these clays are loaded with scattered pieces of ore, fine or coarse; at others they do not show a trace of ore. Sometimes the mass of clay is interstratified with layers of rock ore yielding richly.

The rock-ores and pipe-ores, bedded or in packets, under the clays are also excessively irregular, and nothing but actual mining can teach us the quantities concealed.

But any one who reads carefully the following descriptions of the ore banks taken up in succession, must arrive at the conclusion, that the Railway line connecting the ore deposits of Nittany Valley with Western Pennsylvania over Tyrone, and with Eastern Pennsylvania over Lewisburg, will have within the limits of my map, at its command for freight to distant iron works, many millions of tons of prepared ore of the choicest character.

One of the most noticeable features in the iron history of this district (and of others similar) has been denials of the existence of any ore just where the deposits were proved by subsequent diggings to be most copious, and predictions of the speedy exhaustion of ore banks which steadily grew in magnitude and richness as the excavations spread. The history of Pennsylvania Furnace Bank affords a notable instance, and not an isolated one.

There are not less than 100,000 linear yards of ore belt on my map. If the ore were continuous, and only 50 yards wide by 10 deep, we should have 50,000,000 cubic yards of ore ground. If only one-tenth of this were ore, we have 5,000,000 cubic yards of ore. It only needs to look at the number, breadth and depth of the diggings, and their distribution on the map, and to remember that none are noted there but the principal cuts; that large spaces of ore belt have for various reasons never been explored; that in some the ore is seen going down to unknown depths; and that in all the banks water has stopped work—to appreciate the inadequacy of the above calculation.

SPECIAL DESCRIPTIONS.

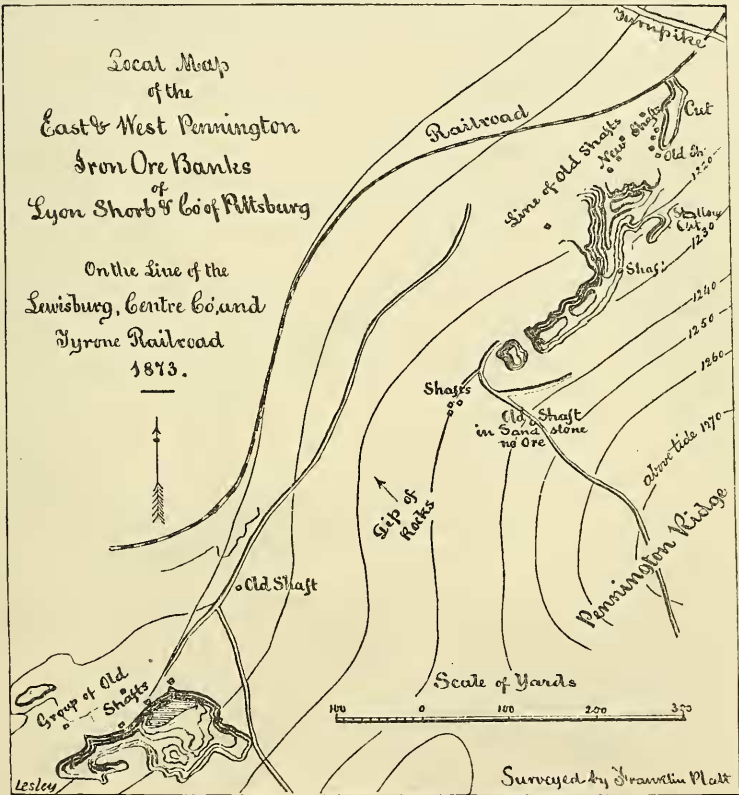
I postpone further economical considerations to introduce here the data upon which what I have written above is founded. The situation and character of the principal mines, are given succinctly, but sufficiently in detail to permit others to form their own opinions.

THE PENNINGTON RANGE.

Cross section A B, fig. 2, shows the ore-bearing limestones at the Pennington Banks dipping *northwest*, and the hard limestones in the quarries on Logan's Creek dipping also *northwest* 23° to 27° , increasing (as we descend the creek) to 90° , and in some places overturned; then, rising again to 53° , 54° (S. E. dip), to shoot over the Bald Eagle Mountain.

Cross section A B shows the same ore-bearing limestones at a point on the road to Huntingdon Furnace, a mile and a quarter southeast of the

FIG. 8.



Banks, and on the opposite side of the Ridge, dipping gently *southeast*, and making a strong outcrop of ore ground.

These are our elements of structure. Taken in connection with those of the Little Juniata River section, fig. 1, the geology is evident. There is a low anticlinal arch in the Pennington Ridge, and a sharply plicated little synclinal trough in the Valley of Logan's Creek.

The Pennington ore rocks descend into and beneath Logan's Creek Valley, at first slowly, then steeply, at last vertically, and before reaching the surface again on the other side of the little synclinal, are cut off by the great fault, and are sent down by it to a depth of many thousand feet beneath Bald Eagle Mountain.

On section line C D, fig. 3, no such structure appears; consequently the little Logan's Creek synclinal does not range away northeastward along the foot, but cuts across more northward into the flank of Bald Eagle Mountain.*

As for the Pennington Ridge anticlinal, it loses itself in the hill north of Warrior Mark Village, and in the great fault further on. Obscure dips† of 75° to 80° (N. W.) are seen in calc. sandstone at 500 yards northwest of the village, and 80° (N. W.) in blue limestone, at 450 yards further up Warrior Run; but the universal slant in the country, from here onwards, is southeast; all the outcrops beyond or northeastward of Warrior Mark Village belong to the *southeast* side of Pennington Ridge.‡

The Pennington Bank ore range is therefore a short one, whereas the next ore-range to the south of it runs continuously through Warrior Mark Village and Love Town for ten miles within the limits of our Map.

The Pennington ore rocks are also of an older age than those of many other banks in the Valley, as the sections show. They belong rather to the lower than to the middle division of the Great Limestone Formation. The Pennsylvania, Hostler, and other banks on the Spruce Creek side belong to the middle division. Any constant difference of quality observable between the ores is of course to be ascribed principally to this fact, viz.: that the ore bearing rocks being deposited in two successive ages, and therefore under different conditions, their present dissolubility and receptivity (as regards soluble salts of phosphorus, sulphur, &c.), have bestowed on them peculiarities of individual character.

I consider it possible that the Pennington Range corresponds in age with the Bloomfield ore range, in Morrison's Cove, thirty miles to the south.

The Pennington Range proper consists of a line of outcrops commencing about two miles from the Juniata River, and extending two miles to the railroad, a mile west of Warrior's Mark Village. The northwest face of Pennington Ridge is covered with wash-ore to a variable depth, below which lie sheets, belts, and masses of rock ore, between ribs of still undissolved siliceous limerock. The more argillaceous lime beds have left intercalated sheets of white clay.

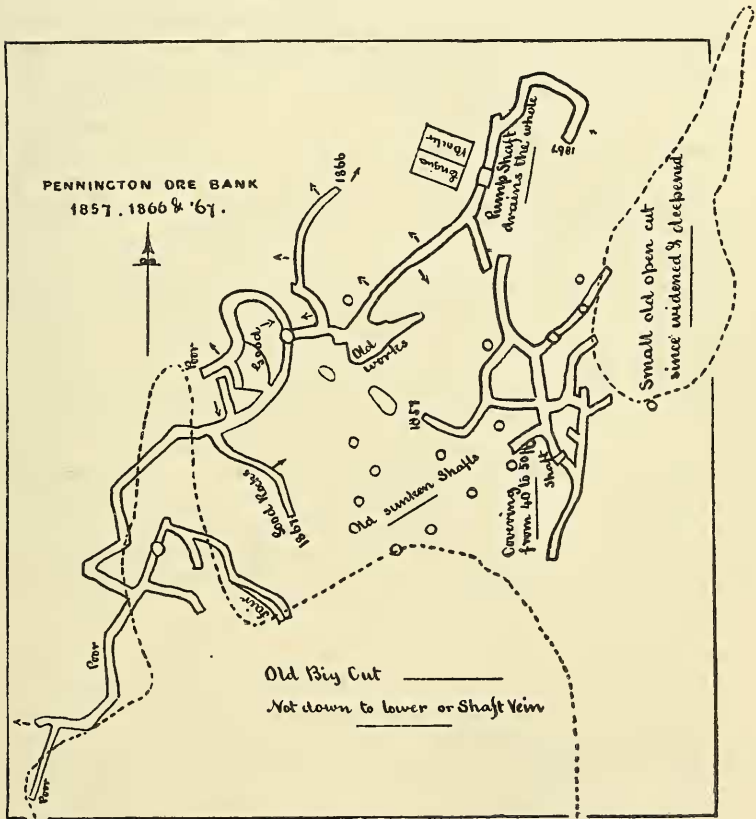
* The Map shows how it swings the mountain a little out of its otherwise straight course, and also how Logan's Creek takes its head just where its synclinal terminates in the mountain slope.

† The cross cleavage of the rocks near the fault makes the direction and strength of these dips doubtful. They look like 30° to 60° (S. E.)

‡ As will be abundantly evident to any one travelling along the road from Warrior Mark to Love Town.

No. 1. The Old or East Pennington Bank, supplied Bald Eagle Furnace with stock for many years. The ore was hauled about four miles over the mountain. It was chiefly got from the large open-cut shown in Local Map, fig. 8; but also from underground gangways following the ore down the dip (N. W.) beneath a clay covering; and from shafts sunk on that side, tunnels or rooms being driven from the bottoms of the shafts irregularly in every direction at the caprice of uneducated miners, who groped always in the dark, without correct geological ideas to guide them, following what they imagined to be the thickest beds and belts of the

FIG. 9.



best ore, and leaving all the rest to stand and be covered up again by the annual tumbling in of their shallow works. Most of these miners were Irish laborers paid by the ton. Water invariably stopped them, and limited the range of workings to a comparatively narrow belt down hill. The great deposits of ore unquestionably lying to the deep (N. W.) are unexplored. Neither maps nor notes of the old works exist.

Fig. 9 is a reduced copy of maps made by Mr. H. V. Böcking, mining manager of the Company, to show the position of shafts and direction of tunnels executed under his direction, in a more systematic way.

At the east end of the Old Bank, Mr. Böcking did much sinking on lower ground. One old shaft which had been abandoned at the depth of 30 feet on account of water, he sunk 30 feet deeper to the sandstone floor of the ore, which drained the mine. A cross-cut from this shaft 75 feet long struck the ore descending (N. W.) but where it was nearly level. Galleries were then driven and much ore won in an irregular way. But the heavy spring rains of 1857 filled the works to the top of the shaft. At this time the large deposit at McAtear's (West Pennington) Bank was discovered. In 1865 a new shaft was sunk, in a dry season, a little north of the caved-in works, reaching the bottom of the ore at 45 feet. The shaft was 60 feet deep, and a steam-pump kept it dry by two or three hours work per day. A good vein of ore had been abandoned (on account of water) in a smaller open cut, near the last mentioned shaft, with only 3 or 4 feet of dirt covering to the ore.

That the rich deposits of ore in the old open cut pass down northwestward, in irregular but continuous floors and layers between the clays, was proven by galleries driven by Mr. Böcking west from the pump-shaft, see fig. 9. He describes these galleries as driven in wavy ore, meeting several good bodies of ore. No pillar mining was done, as the sinkings were merely tentative.

In all this no account is made of anything but the better streaks of hard lump or rock ore, which alone a small charcoal furnace is willing to smelt. Great quantities of saleable ore and wash-ore are ignored.

My assistant, Mr. Franklin Platt, obtained the following information on the ground while making his map:—

Beginning at the Railroad, the first and smaller pit (now filled with water) 70 yards long, by 15 wide and 5 deep, yielded about 5000 cubic yards of wash-ore, without any solid lump ore. Shaft No. 1, sunk near it, (N. W.) is said to have passed through

- | | |
|------------------------------------|----------|
| 1. Top wash-ore..... | 15 feet. |
| 2. Rich lump-ore..... | 5 “ |
| 3. Clay with little or no ore..... | 25 “ |
| 4. Good lump-ore..... | 15 “ |

the bottom not reported. Shaft No. 2, (W.) had lean wash-ore on top; clay to 40 feet; good lump-ore thence to bottom at 50 feet.

The main open cut is 230 yards long, with an average width of 35 yards, as shown in fig. 8; depth from 5 to 8 yards. Wash-ore, sometimes lean, forms the wall of the pit, from the surface to an apparent depth of 15 feet. A shaft midway of the eastern edge, “struck a layer of ferromanganese ore, 5 feet thick, at a depth of 15 feet.”

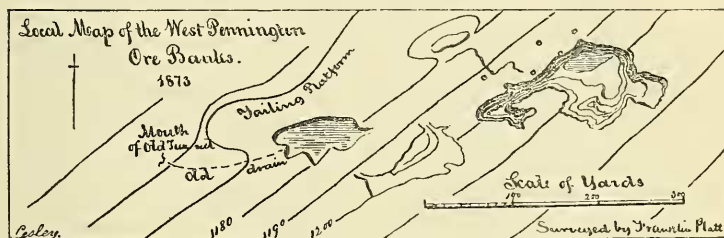
Two-thirds of the distance from the southern to the northern end of the pit, a massive crop of half decomposed calciferous sandrock charged with more or less of ore, juts from the wall, dipping gently northwest.

Some of this rock is genuine iron ore; the rest ferriferous or merely ferruginous sandrock. The excavated ore lay over, under and around this rock, having been freed from other similarly dipping, but more ferriferous and more dissoluble strata.* It is a place where the genesis of our brown hematites may be studied to advantage.

Ore was found in some of the shafts to the south-west of the main open cut.

The whole N. E. and S. W. extent of this uninterrupted expanse of wash ore, from the railway track to the shafts last mentioned, is about 500 yards, and its width, say, 100 yards. A considerable percentage may be too lean to wash.† Estimating the depth of soft and hard ore at 10 yards, we have 500,000 cubic yards. Rejecting one half for leanness, we are safe in supposing 250,000 cubic yards of ore in sight.

FIG. 10.



No. 2. The West Pennington Banks. An interval of half a mile separates this open cut from the East Pennington Banks last described.‡ The railroad, curving across a slight hollow in the side of the ridge, see local map, fig. 3, approaches within two hundred yards of the north

* The strike of this rock is *across* the open cut, here very narrow. The ore of the northern end of the cut is therefore above these rocks, and that of the southern portion of the cut belongs below these rocks.

† The "black ore," which is very rich, is in some places abundant; in other places it becomes very thin.

‡ Mr. Böcking, speaking of this interval, says that after passing a low place at Me-Atear's, the main body of good ore was discovered in 1857, at the surface, on ground into which old pits had been sunk, the miners having previously condemned the whole locality. The very rich deposit then discovered lay higher up the slope of the ridge, and had thus been entirely missed.

Mr. Platt remarks: "What the original shape of the ore on the face of this ridge was, it is now hard to say; but the two Pennington ore deposits are at present separate and distinct, not necessarily connected in any way. I presume that the original limits embraced them both, and much of the ore lying between them which is now gone."

This agrees with what is seen at the Pennsylvania Ore Banks, to be described hereafter, and it is a strong argument in favor of the wholly outcrop character of these brown hematite deposits. On the other hand, the ore has never been properly followed to the deep, and the distance in that direction to which the dissolution of the ferriferous limestones and the precipitation of peroxide of iron has extended is unknown.

wall of the excavation, see fig. 11, which is 180 yards long, by 40 wide on an average, and shows nothing but wash ore in its banks. Its very irregular depth may be called 10 yards; water standing in the floor.

This cut was worked to a depth of 40 feet during seven years, and yielded richly. The first maps are lost. Mr. Böcking's underground works on the north wall, commenced in 1865, are represented by his Local Map, fig. 12, and thus described by him:—

An old whin shaft was pumped out, and pillars robbed. The galleries then caved in, and work stopped. Ore can still be reached from other shafts, two of which are timbered. One body of ore lies between the old cut and the underground works. It is not very rich, but is "good natured," and mixes well with more refractory ores. Another body of good rich ore remains standing to the deep of the works, and has a heavy covering. Another body of very good ore, fifteen feet thick, occupies a trough below the level of the pump-shaft, estimated at say 500 tons. Shaft 5 has ore around it. Shaft 4 is in a fair vein of rock ore. The deposit at shaft 3 is variable, and part of it stands. Old cuts and pits show that the deposit runs on southwestward.

That the ore extends northwards is shown by the late railway cutting 200 yards north of the open cut (see fig. 10), where ten feet of wash ore is seen overlying white and red clays.

Seventy yards southwest of the main open cut is another, 110 yards long, 15 wide, and 8 deep (13,200 cubic yards), nothing now showing but wash-ore in the side walls. It was originally much deeper, slides having partially filled it.

Three hundred yards west of the main open cut is the Old Phillips Bank, $100 \times 30 \times 6$ yards (18,000 cubic yards), full of water. It was once deep, and drained by a tunnel, the mouth of which is shown on the Map (fig. 10), 140 yards from its west end.

Calling the length of ground occupied by these three open cuts, with their imperfect underground workings, 400 yards, and its breadth 100 yards, and assigning an average depth of ten yards for wash and lump-ore, we get an original mass of 400,000 cubic yards, one-half of which may be considered rich and accessible enough to work to advantage.

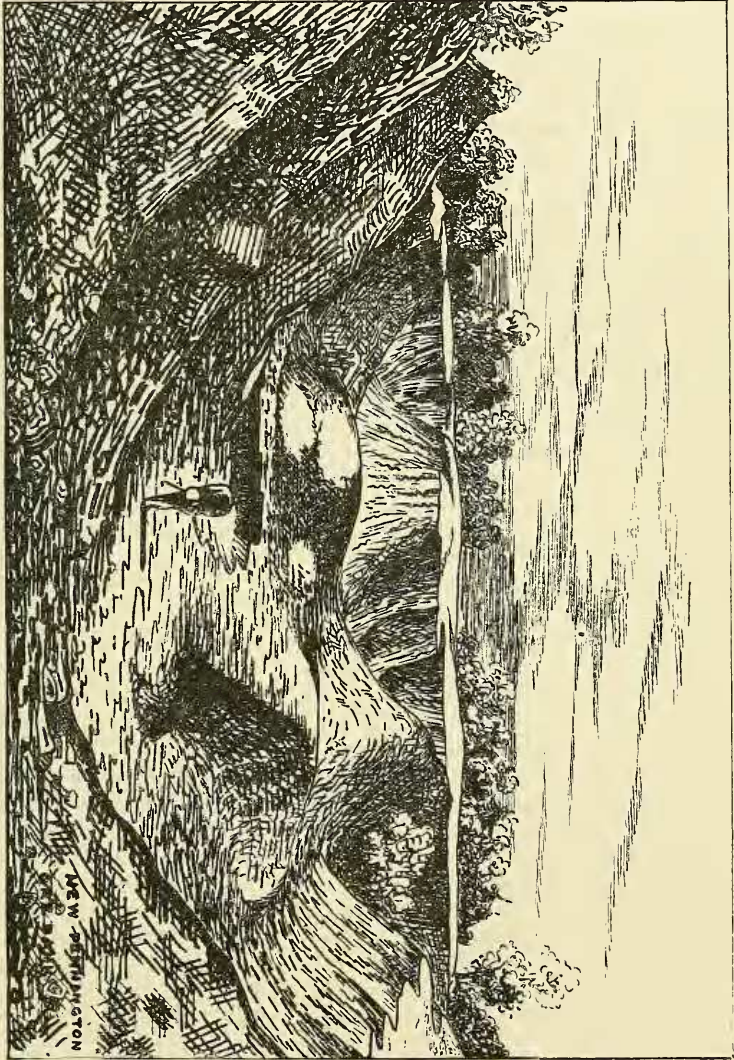
But it must be considered that this Pennington Range of deposits shows a much stronger tendency to develop lean layers and sandy masses than the Dry hollow, Red, or Gatesburg Ranges, hereafter to be described. Estimates of workable quantities are, therefore, hazardous. We are here geologically at the bottom of the limestones, and close on the top of the "calciferosus sand-rock" formation, which accounts for the tendency to sand-rock and sandy ore exhibited in these banks.

Of the old Phillips bank Mr. Böcking says that it holds purplish easy smelting ore, mixed with clay, and without discernible regular veins. Quantities of wash-ore can be got here; but *dry* screening is impracticable.

This gives the key to the problem of the future. The near presence of

the railway makes systematic mining along this range a very different affair from the "ground hogging" of the surface hitherto pursued, un-

FIG. 11.



systematic, wasteful and costly as it of course was. A regular stoping of the deposit on a large scale and the washing of all the ore ground must yield a profitable revenue.

Mr. John W. Harden, an experienced Superintendent of mines, considers the extensive dry tailings, which cover the slope to the north of the cuts, capable of being profitably washed, while being got out of the way of future open cuts.

Traditional accounts of such old ore mines as these are to be credited with due caution and large allowances. But they have their value. It is of great importance, then, that shafts of over a hundred feet have been repeatedly sunk along this range; for they are proofs that experience has justified them; proofs that bodies of ore had been found lying very deep beneath the surface. The open cuts exhibited by the maps (figs. 8 and 10) were once very deep and were stopped by water, *as has been the case with all the ore banks of these valleys*. The miners were always driven from fine beds of rich rock-ore by the influx of water which they had no adequate machinery to keep under. We can easily believe it therefore, when we are told that in the Old Pennington Bank a floor of massive rock-ore from 8 to 16 feet deep underlies 50 feet of a covering, consisting of wash ore and scattered lump ore intercalated between white variegated sandy clays; and that in the West or New Pennington banks the deposit consists of a surface soil with a little ore 5 to 10 feet thick; then wash ore interstratified with layers and masses of white, brown and red tight clays and loose sands from 50 to 80 feet, and a floor of red rock ore underlying all.

My own belief is that when pumping machinery of adequate power comes to be applied to these deposits, and an approved system of mining adopted, many hundred thousand tons of ore will be raised and sent to the eastern furnaces at a living profit.

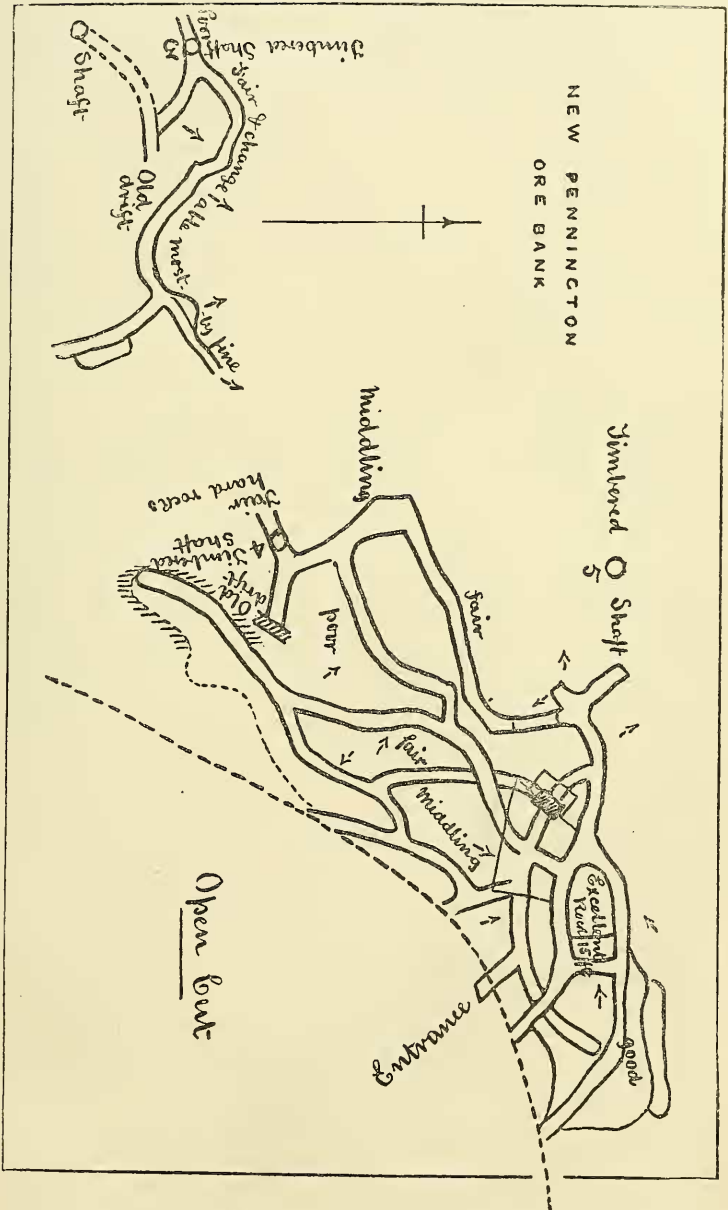
The southwestward extent of the deposits is unknown. But on the southwest of the ravine and hill spur beyond it a pipe-ore and a good deal of "barren ore" mark the continuation of the *Pennington outcrop* through D. Bronstetter's fields, and then across Gyer's farm. It is cut by a gap; and then is again visible crossing Weight's farm, and (on the west land line) reaching to the hill-top. Hence to the Juniata it is hard to trace; but becomes visible again west of the river in Sinking Valley.

No. 3. Beck Bank (marked "nameless" by mistake in the Key List on the large map).

The eastward extent of the Pennington deposit has not been carefully explored; but at the entrance of a R. R. cut, half a mile east of the Old Pennington Bank, Huntingdon furnace mined ore 10 years ago. This Bank shows $40 \times 20 \times 5 = 4000$ cubic yards of excavation, with water in the floor, and wash ore walls, rather lean in quality and quantity, as now visible.

No. 4. New Town Bank, also called **Beck's** (and so designated on the large map), lies $1\frac{3}{4}$ mile east of Old Pennington Bank, and was worked for Bald Eagle furnace, and abandoned for want of pumps to

FIG. 12.



keep down water, "good ore being left standing in the floor." In the woods behind Beck's and Aul's fields, north of it, small shafts were once sunk on fine sized ore. In Beck's Bank wash ore is seen in the walls, showing rather lean. At present there is not much evidence of the presence of a considerable deposit, and no encouragement is felt for looking for it.

The road to Warrior's Mark Village descends to Warrior's Run, past New Town Bank, which seems to be the remains of a surface deposit once covering the flat top of the Pennington Ridge Anticlinal. It is the only mine on this southeast dipping outcrop that has ever been opened west of Warrior's Run. But, that the ore belt extends in that direction, towards the Juniata, is proved by the heavy outcrop of ore ground, shown on the large map and on Cross Section A B, fig. 2, $1\frac{1}{4}$ miles due south of the Old (east) Pennington Bank.

The vein of ore pursued by those who worked the New Town Bank is described as small and irregular in thickness, and not traced successfully downhill and westward; but much coarse ore covers the ground in Jer. Berk's fields, on which the Furnace had no right to enter; slight shaftings showed small veins of ore. Further west also, in Adelberger's fields, some ore was raised; and outcroppings occur on P. Cooken's farm.

WARRIOR'S MARK AND LOVETOWN RANGE.

From Warrior's Run, north-eastward we have almost a continuous series of shafts and open cuts for a good many miles; viz:

Old Town Bank (V) is $\frac{1}{2}$ mile east of Warrior Run; Romberger's Bank (VI) $1\frac{1}{2}$ miles; Hannah Bank (VII) $1\frac{3}{4}$ miles; Waite's Bank, $2\frac{1}{4}$ miles; Lloyd Braunstetter's Bank (IX) $2\frac{3}{4}$ miles (with pipe ore outcrops to the south of it); Disputed Bank, $4\frac{3}{4}$ miles, (X); Hannah Furnace Bank, 5 miles; Hannah Furnace and Beck Banks half a mile north of the last two, and less than a mile west of Lovetown; the pipe ore outcrops half a mile south of Lovetown; croppings near the sawmill, 2 miles east of Lovetown; Hannah Furnace Bank and Bryan Bank, $2\frac{3}{4}$ miles east of Lovetown, and the Curtin Bank 5 miles east of Lovetown, and 11 miles from Warrior's Run.

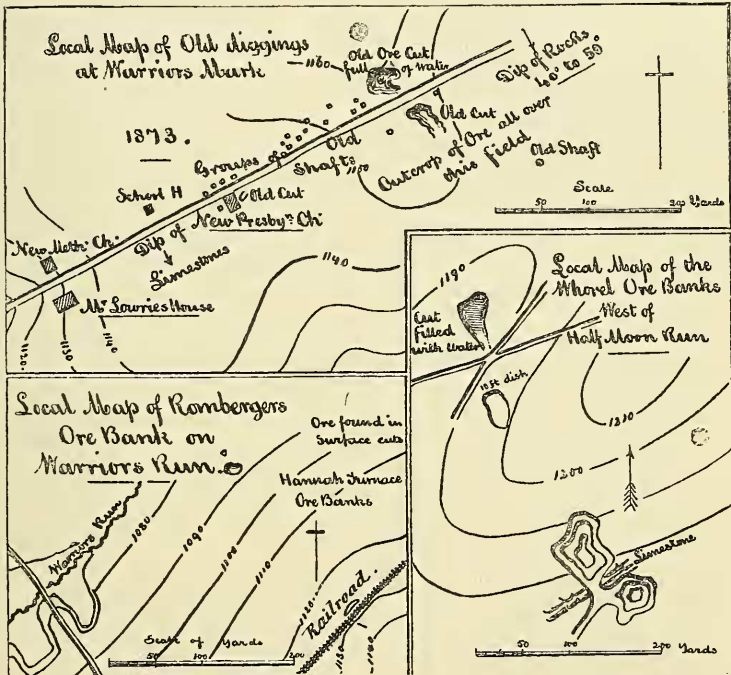
The ores of these Banks, when rich, are black or dark colored, much of it of a pitch-like lustre, and often inclining to cold-short in quality. Dr. Genth's analyses in my appendix will give their chemical constitution. When lean, they are of a lighter color, brown, or liver colored; clay predominating over sand in the deposit, as compared with the Pennington ores proper. Some of them may occupy a slightly higher geological position, being still further removed from the upper layers of the Calciferous Sandrock, and lying, therefore, still more in the body of the Trenton Group* of Limestones.

* See sections A B and C D. The Trenton Limestone proper, of the New York Geologists is considered to be the top member of the Trenton group. Our ores are far below it, and in the lower members of the group, viz. the Chazy, Bird's Eye and Black River Limestones.

No. 5. Old Town * Banks, are shown on Local Map, (fig. 13,); two old open cuts, one on each side of the main road, and groups of shafts, principally north of the road. There is a decided ore-show on the surface for 470 yards. Opposite the new church, an old shaft reached a maximum depth of 110 feet, touching "a vein of ore." (Böcking.) Contradictory accounts are now given of this work. Some say, that the quantity of ore was enormous, timbers 30 feet† long being used to support the chambers, the ore dipping steeply N. W.; and that massive

FIGS. 13, 14.

FIG. 17.



ore stands in the sides and at the bottom of the deserted mine. Others say, that the ore mass, 25 feet thick, descended vertically with undiminished size when the shaft was abandoned. It is may be a deposit in one of the ancient caverns or cross fissures of the Limestone Formation.

Shafts sunk to depths of 30 and 50 feet sometimes went through clays without ore. Mr. Böcking sunk one 80 feet deep to find a mass of ore said to exist between three old shafts, but found nothing. The surface wash ore is sometimes only 2 or 3 feet deep; in other places 20 feet. No

* Called Town Bank, on the Local Map.

† The rocks of the neighborhood dip 25° to 35° S. E.

estimate of quantity is possible with such information. The visible area measures about 67,500 square yards.*

A little pipe ore has been found higher up the hill north of the road.

Regular and progressive stoping from the south-west, along the belt, may produce large results in the future. But the oreless clay of great thickness intervening between the surface wash and the deep hard ore will make mining expensive.

No. 6. Rumbarger's Bank, (Local Map, fig. 14,) is an open cut in the south bank of the east branch of Warrior's Run, the surface of the ground only rising 6 feet above the bed of the stream.

A cross-road separates the excavation into two; that on the southwest, $40 \times 40 \times 10$ yards deep; that on the northeast, $30^1 \times 30 \times 10$ yards deep; 25,000 cubic yards in all. These pits reached a depth of 40 feet, wholly in wash-ores and clays, without striking solid limestone. The rock ore left in the bottom when the work was drowned out, is *reported* to be less abundant than that found above it. But as the ore streaks "dipped fast to the southeast," and the limestone out-crops of the neighborhood dip from 22° to 34° in that same direction, (see Large Map,) good mining will probably yield well. Plenty of good ore has been won here, and nothing but the lack of pumping machinery stopped the winning. Thos. Funk worked the Banks at one time for the Milesburg Company.

The ore belt passes on eastward under Is. Buck's (now Smith's) lands, where Messrs. Green of Barree raised ore, but took no sufficient means for establishing a mine.

Thence it enters and underlies S. Hanna's farm, with its numerous ponds and sink holes, full of promise for the future.

A mine for Bellefonte Iron Works has just been opened (August, 1873,) at a point 300 yards northeast of Rumbarger's Banks, (see Local Map, fig. 14,) where a very heavy outcrop exists. Every cubic yard is washed profitably. The cut is yet only 4 or 5 feet deep.

As a heavy surface show extends 150 yards beyond Hannah Bank, we have here an area of $450 \times 50 = 2250$ yards of wash ore of undetermined depth; besides the rock ore undoubtedly existing further down.

Mining and washing will here be cheap, and the railway runs along the hillside at a distance of 200 yards, and at an elevation of 35 feet, (fig. 14).

Further on, the surface show is slight, or wholly wanting,† until we reach the next excavation.

No. 8. Waite Banks, shown in Local Map, fig. 15, consist of two pits, $100 \times 20 \times 7$, and $90 \times 20 \times 7 = 26,000$ cubic yards, in size,

* Ore is found in the soil of Petershoff's farm on the south of the Town Banks. There is an old digging on the Hyskel (B. M. Thompson) farm; and further west outcroppings on Thom. Gano's, whose trial pit on a small vein near his orchard was stopped by water; lively outcroppings show in several fields up the slope of Dry Hollow ridge.

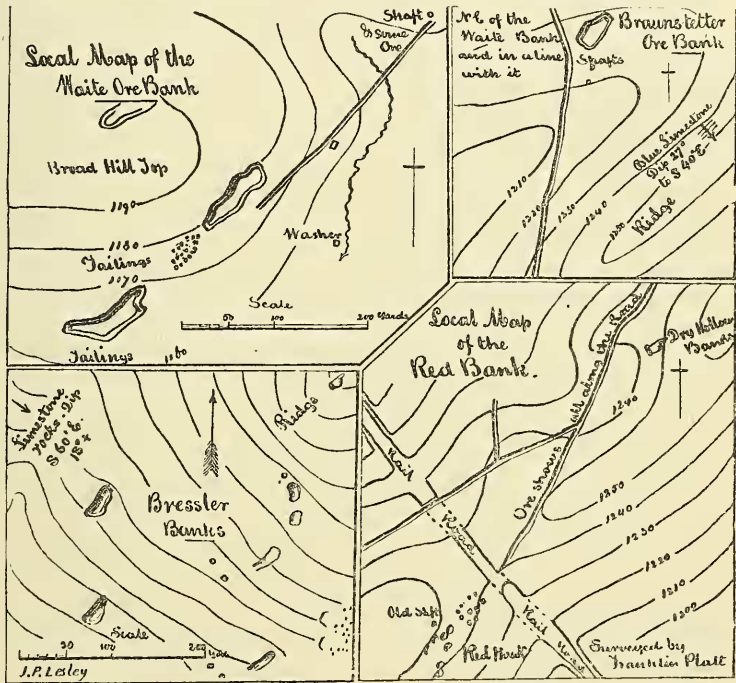
† A shallow pit $\frac{1}{2}$ mile from Hannah Bank yielded some ore. The Waite Bank is 400 yards northeast of this shaft.

more than 20 feet depth of good-looking wash ore being seen in the sides, and much lump-ore having been won by still deeper shafts in the intervening ground. The entire ore prism must therefore exceed 150,000 cubic yards. The Railroad is a mile distant.

No. 9. Braunstetter's, or the McGlathery Bank, is situated about 1200 yards beyond (N. E. of) the Waite Banks, and the interval shows little on the surface; yielded only some lean ore to one or two trial

FIGS. 15, 16.

FIGS. 18, 19.



pits. This Bank, (see Local Map, fig. 18,) is only $30 \times 20 \times 10 = 6000$ cubic yards large. It is said to have been worked to a depth of 40 or 50 feet, but is now fallen in and full of water, and no one seems to know much about it. Overlying Limestones crop out 150 yards southeast of it, dipping 27° S. 43° E.

Further on is the old Disputed Bank, on the high divide, between Warrior and Half Moon waters. Here are several small shallow open-cuts and shafts in surface ore; but no deep mining has ever been attempted. The ore seems to dip south, and is sandy. The crop traced westward, becomes good and plenty on Jos. Bronstetter's farm, who has never made

judicious trials of the deposit, and through the hollow leading to Patton's (now Waite's) and the Lloyd Bank, above mentioned.

No. 10. The Lovetown Banks, consist of numerous open-cuts and shafts from which large quantities of ore have been extracted and extensive preparations are in progress for regular mining of this important part of the ore field. The principal outcrop occupies a vale watered by a small branch of Half-moon. The old shafts of Abram Love were stopped by the influx of water. Pipe ore is visible near Love's barn. Half a mile west is an old "exhausted" Hannah Furnace Bank. On the north slope of the ridge west of Love's, ponds and sink-holes abound. Hannah Furnace had a Bank in David Berk's fields, and abandoned a good deposit of ore in its floor, merely on account of water. Surrounding shafts were also sunk, but no pumps were ever planted. A few hundred yards west of the open-cut, some of these shafts went through a pretty good "top vein" into a regular deposit 20 feet beneath the surface. Southwest of this other shafts were sunk for the Milesburg Company, in Abed. Stevens' fields, in good rich, sandy, black ore, close under the sod, the poorer clay ores lying down on the limestone foot of the hill. South of this, John Stine gathered much loose heavy ore from his fields, and hauled it to Bald Eagle Furnace, many years ago; but no sinkings were done. The outcrop is noticeable in Jos. Bronstetter's lane (leading to Wrye Bank) and in his fields on Cronister's line.

The Lovetown Banks are shown on Local Map, fig. 20, occupying two vales, descending eastward to the Half Moon Run, at the mill-dam.

A rib of solid blue limestone strata, dipping S. 30° E. $> 56^{\circ}$ to 57° , forms a low hill, up the south slope of which the wash-ore rides on to the flat summit. Natural ponds occupy, at points, the beds of the two vales.

The north line of the Love property commences near the Beck Banks, and runs down the northern vale to the corner of the mill-dam. The ore has been open-cut at Station 37, 165 yards west of where this line crosses the road. This once deeper old cut is now only ten feet deep, showing in its walls liver-colored, somewhat lean, wash-ore. West of it is a series of shafts for 450 yards, formerly sunk 60 or 80 feet (without timbering) until water was reached, and after a little side-drifting, abandoned. Hannah Furnace ran for some time entirely on the ore got in this primitive fashion from these holes. In one of them (St. 39) pipe-ore was found. Nothing more is now known of them. They are evidently on a continuation of the Beck Bank deposit, the result of decomposition of ore-bearing strata *underlying* the rib of blue limestone at Station 56.

The rest of the ore on the property belongs to the series of rocks *above* the blue limestone, and to the southern vale.

The first shafts are sunk near Love's house. Shaft A struck ore at 35 feet; B, pipe-ore at 35 feet. Ore has recently been found southeast of A, on the foot of the opposite hill.

From Station 44 there extends east and southeast down across the

bottom of the vale, and west and southwest along the hill-slopes and hill-top, a universal surface deposit of wash-ore. In this area are numerous old shafts, pits, and open-cuts, and some new shafts sunk this summer and fall. The old works were always abandoned on striking water at various depths down to 80 feet, and are now filled up, and no records preserved. Much ore was certainly mined from them.

The new shafts show that from 8 to 15 feet of wash-ore in clay underlies the surface at the depth of a few feet, and that under the yellow and white clays there lie separate deposits of ore-lumps, the geographical intervals being barren. There seems to be no regularity of the ore layers.

The old shaft at Station 48 is said to have passed through twelve feet of surface wash, then (ore-bearing?) clays to a depth of 80 feet, into lump-ore, which was mined for several feet, and left in the bottom when water stopped the works. The new shaft, only ten yards southwest of the old shaft, is down 80 feet, and found no ore in the clays. The ore got seems rich and rounded, as if water-worn.

It may be safe to give twelve feet of wash-ore to the whole area, under which are hard ores, yielding sometimes richly and sometimes nothing.

The surface ore extends 850 yards along the top of the hill. Most of the pits were shallow, but one at Station 59 is said to have been 115 feet deep through wash- and lump-ore, with ore left in the bottom.

The general appearance of the deposit is the same as at the Dry Hollow and Wrye Banks.* No regularly interstratified ore is noticeable. No estimate of quantity can be relied on. Taking only the area of heavy surface show, and calling it 850×300 yards, and the depth twelve feet, we have 1,020,000 cubic yards of seemingly good wash stuff, which, at 3 cubic yards to the ton, gives 340,000 tons.

To this must be added the very uncertain quantities here and there scattered through the under clays. As these have been sometimes locally considerable, it is possible that one or two or even three hundred thousand may thus be obtained. As the principal part of the lump-ore is evidently at the bottom of the clays, no knowledge of the quantity can be got until systematic mining reveals the truth.

Wash-ore ground here must be considered as the main reliance for the present. Washing here is easy; abundance of water is struck at 50 or 60 feet, and there is plenty of room for settling dams. The railroad line, adopted for a branch to the main railroad, rises one mile on a 92 feet gradient, and descends one mile on a 46 feet gradient.

The ore has a much more extensive range than that above described, for Mr. Fisher has opened three small pits on ore just beyond the north-eastern property line; and the Beck Banks show that it passes southwestward into the adjoining properties in that direction also.

An analysis of Lovetown ore, from the large pit at Station 49, fig. 20, made at my instance by Mr. Persifer Frazer, Jr., Professor of Chemistry in the University of Pennsylvania, shows a percentage of phosphorus low

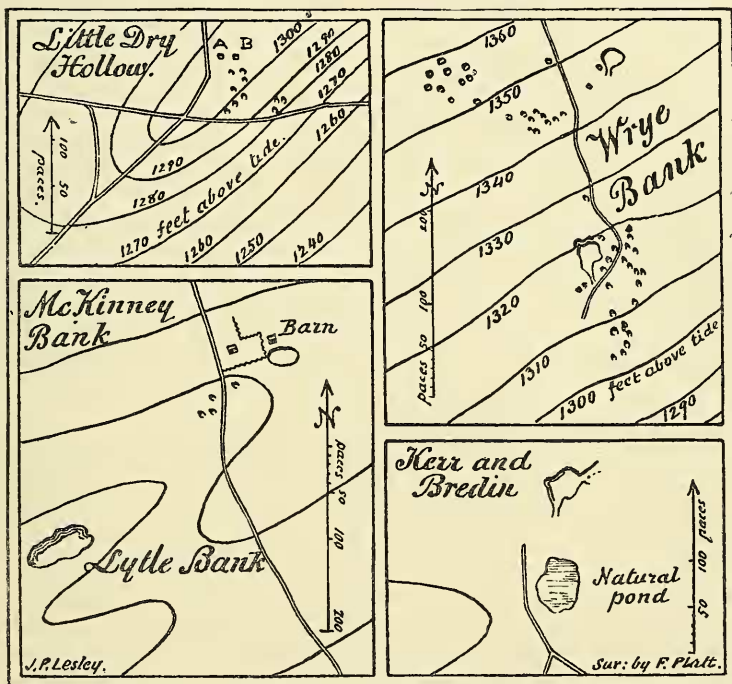
* Hereafter to be described.

enough to bring this ore within the limits of safe use in the manufacture of iron for the Bessemer process. The specific gravity of the specimens was 3.52. The calculated percentage of metallic iron was 45.36; alumina 16.53; silica 6.63; lime 0.58; sulphur 0.04; and phosphoric acid 0.05.

Between Lovetown and Stormstown (a distance of $3\frac{1}{4}$ miles) no ore is visible near Bald Eagle mountain, although considerable quantities of ore lie in the fields just northeast of Lovetown; but on a line parallel with the mountain, and about a mile from its base, in a hollow leading from one branch to the other of Half Moon Run, a very fine outcrop

FIGS. 21, 22.

FIGS. 23, 24.



range of tolerably big pieces of ore, closely covering the surface, runs past the sawmill. It leads directly to the two Bryan Banks, and is therefore important.

No. 11. Lytle's Bank; No. 12. McKinney's Bank. These are the old Bryan Banks, $2\frac{1}{2}$ miles N. E. of Lovetown, as shown at the eastern limit of the Large Map, and in Local Map, fig. 22.

The Lytle Bank was worked a long time ago for Hannah Furnace, and measures about $70 \times 20 \times 10 = 14,000$ cubic yards. Very little lump-ore is now visible, the walls showing about 25 feet thickness of wash-ore.

McKinney's Bank, worked for Pennsylvania Furnace, is much smaller, say $25 \times 20 \times 10 = 5,000$ cubic yards, and exhibits the same aspect.

Shafts sunk between the two excavations on both sides of the road, leading south from Stormstown to Gatesburg and Pennsylvania Furnace, always struck good ore, dipping to the southeast; as do the limestone outcrops of the neighborhood. We have here a prism of ore deposit at least $350 \times 100 \times 10 = 350,000$ cubic yards in size; probably, after all due allowances, quite that many tons of ore.

The Curtin Bank, a long, narrow open-cut on a prolongation of this outcrop, beyond the limits of the map, $2\frac{1}{4}$ miles N. E. of the McKinney, and the Lamborne Bank, $1\frac{3}{4}$ miles further in the same direction, have yielded cold short ores, similar in appearance to the Pennington. These and other works of less importance show the persistent straightness of the outcrop of the ore-carrying strata, parallel with the Bald Eagle Mountain, at the foot of which flows the east or main branch of Half Moon Run, with a limestone ridge* between the Valley of the Run and the ore. The Valley of the Run marks, of course, the line of the Great Bellefonte Fault.

At McKinney Bank we are three miles from the railway, where it strikes and begins to descend Half Moon Run. The Lovetown Banks require a railway two miles long, descending the west branch of Half Moon, with a grade of 40 feet to the mile, or else a railway across the ridge $1\frac{3}{4}$ miles long, with gradients 90 feet to the mile, as described. The line of the road was originally located to Lovetown, and thence down Half Moon; but it was considered more desirable to carry it across the Dry Hollow, among the ore-banks to be hereafter mentioned.

Before returning to these banks and the neighborhood of the railway, I will describe a group of banks lying south of the Lytle and McKinney Banks, at the east edge of the map, and on outcrops somewhat higher in the Lower Silurian Series.

DRY HOLLOW RANGE.

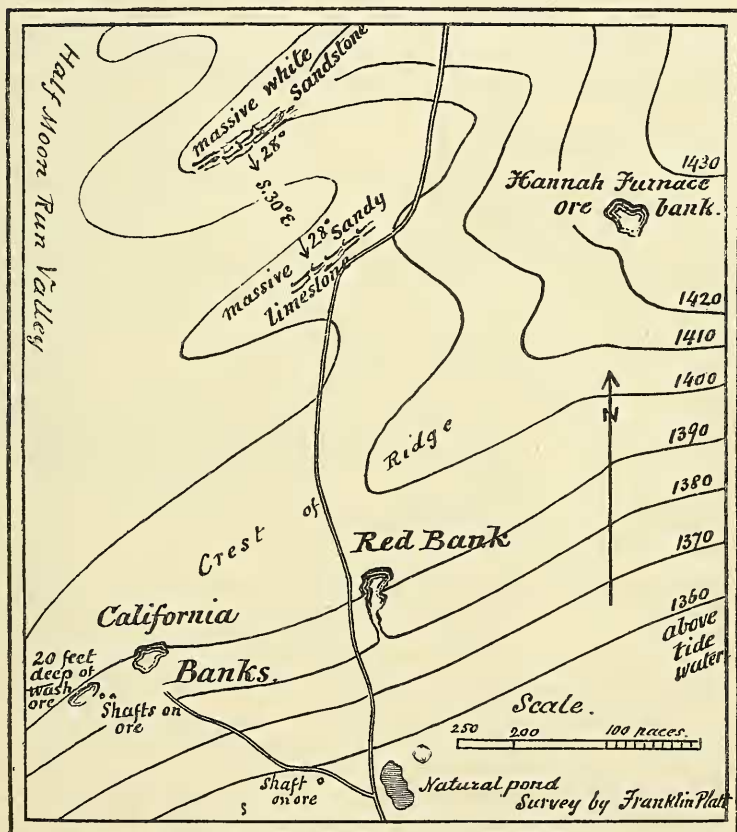
No. 13. Hannah Furnace Bank No. 2. Two hundred yards east of the Gatesburg road is a hole $40 \times 20 \times 10 = 8,000$ cubic yards in size, excavated on the broad, flat top of a ridge, as shown in Local Map, fig. 25. It was long ago abandoned. The ore seems good and abundant, 15 to 20 feet of wash-ore showing in the side walls, and coming close to the surface. All the down-slid stuff may be washed. Massive sandy limestones, 180 yards N. W. of it, dip S. 30° E. > 28 ; 150 yards further N. W., massive white sandrocks dip the same.

No. 14, Bull Banks, half a mile east of the last, and in line with it, consist of two excavations on the south brow of the ridge; see A and B, local map, fig. 27. Much sandy ore was formerly taken out before these banks were abandoned, 20 years ago. $A = 60 \times 50 \times 10 = 30,000$, and

* This ridge, by an oversight, is not represented on the Map, no surveying having been done north of the McKinney Banks.

$B=80 \times 40 \times 10=32,000$ cubic yards. A shows wash ore in the side, which is 30 feet high above the water in the bottom. B shows about 30 feet of reddish wash ore, with very little lump ore, from the water to the surface of the hill. A neighbor who had worked in the pits, reports that several feet of deep brown richer ore was found lying everywhere in

FIG. 25.



both banks beneath the mass of reddish leaner ore. All this awaits the time of improved mining with pumps and washers.

Fig. 27 shows other old workings in the same deposit from 600 to 800 yards to the south-west of A and B. From two of these there have been taken about 15,000 cubic yards of wash-ore, which still exhibits itself 20 feet deep in the walls; the one furthest to the north-west in fig. 27, has been deep, say 40 feet, but now, like all the larger cuts, has standing water and mud in its bottom. Numerous shafts, all yielding ore, give

us data for calculating an ore prism in sight of, say $150 \times 200 \times 10 = 300,000$ cubic yards.

No. 15, Pond Bank, No. 1, worked for Pennsylvania Furnace, lies in the hollow at the foot of the ridge, $\frac{3}{8}$ mile south of the Bull Bank, see local map, fig. 20. Its honeycombed, rather light, easy smelting ore, (mixing well with the more sandy ores of the Bull Bank Hill,) dips also south-east, and therefore belongs to a limestone out-crop still higher in the series, which is sufficient to account for its different quality. A great deal has been removed from this Bank; but much still remains to be won, and water to wash it is abundant. This is included in the prism of ore calculated last above.

No. 16, Red Bank, (Floyd's Old Bank) at the road side, half a mile south-west of the Pond Bank, (see Local Map, fig. 25,) is a cut in the same out-crop. The amount of ore is therefore very great; for the continuity of the deposits has been fully proven. The red rock-ore (35 or 40 per cent.) descends in a solid stratum from 8 to 10 feet thick, at a dip of about 25° to the S. E. Over this lies a stratum of white clay, 3 feet thick. Over this black ore in solid masses and great lumps scattered thickly or thinly through several yards of wash ore, to the surface. Some of these lumps are 2 feet long by $1\frac{1}{4}$ feet thick.

This Old Gatesburg Bank, as it is sometimes called, was worked 40 years ago, and has been re-opened now to show its character.

The red ore was too siliceous, and hard to work in the small cold blast charcoal furnaces of the region; but it will be eagerly sought by modern hot blast coke or anthracite furnaces.

The black ore masses were selected for charcoal cold blast use, having 50 to 55 per cent. of iron and being fusible ore.

It is impossible to say how deep these strata descend on their 25° dip in a peroxide condition. But allowing only 100 feet, we have in a mile of outcrop 150,000 cubic yards of red rock ore; and as the wash ore ground holding the black lump ore descends with it, and spreads over a belt of surface more than 100 yards wide, there must be half million cubic yards of it at the lowest computation.*

The old cuts at the elbow of the road west of the two ponds in fig. 27, have had about 8000 cubic yards excavated and are now filled with water to within 10 feet of the surface, showing that much wash ore without lumps. The two larger cuts 150 yards north-west of them, measure about

* I have described above only what I saw. Mr. Platt was informed that under 12 feet of clay holding black lump ore, lay 4 feet of white clay without ore, under which lay 14 feet of red rock ore in red clay, and ore was still underfoot. I give this report for what it is worth.

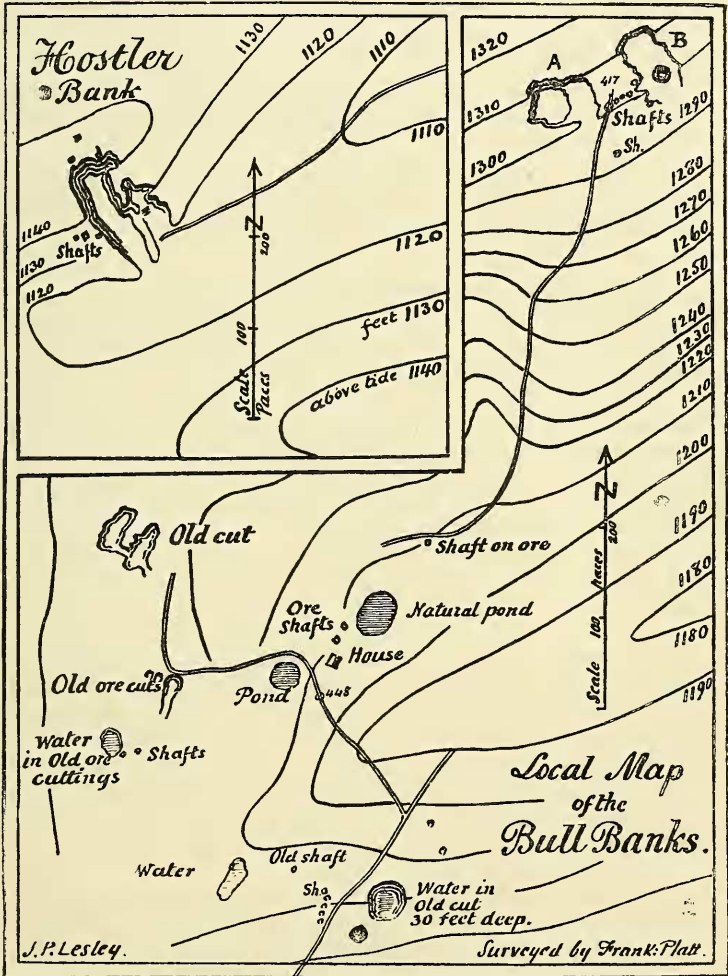
Mr. Böeking speaks of red rock ore only 6 feet thick, "and another fair layer in the clays above, all workable; red ore not very rich; silicious, but with visible sand; rich black ore in the top vein, [the word he always uses for a stratum of ore]; on the whole, proper for coke furnace use; mining requiring pumps; deep workings at hand; an important locality."

15,000 cubic yards, with 21 to 25 feet of wash and lump ore in the walls ; abandoned 20 years ago.

No. 17. California Bank, 200 yards west of the Red Bank, and on the same slope and outcrop (see Local Map, fig. 25, (received its name from

FIG. 26.

FIG. 27.



the richness of its ore, before it was abandoned 20 or 25 years ago, on account of its distance from Pennsylvania furnace, the abundance of water and lack of pumping apparatus, the refractory quality of its mineral in the cold blast charcoal stack, and especially the abundance of

good ore at the Furnace itself. Pits of standing water show 20 feet of wash ore in their walls.

This completes my sketch of this "dry hollow" outcrop east of Half Moon Run. It is a dry hollow because the whole limestone underground is cavernous, and water springs up abundantly in every excavation, but does not flow over the surface. This is a prime factor in the problem of the genesis of these ores, and must be taken into consideration in all speculations respecting the depths to which the brown hematite ores descend in a minable form.

The outcrop belt of surface wash ore and regular rock ores in which the Hannah Furnace, Bull, Pond, Red and California Banks are excavated, passes on north-eastward into the untried wilderness of the Barrens, where we find upon it the Floyd Bank, an open cut on highland; ore very sandy for charcoal furnace use, but good and abundant for hot blast coke or anthracite; and good charcoal ore could be selected from it still.

No. 18. Reider's Bank, half mile east of Gatesburg, is a small surface opening of $30 \times 20 \times 5 = 3000$ cubic yards extent. On trial at Centre and Hannah Furnaces it was refused. The surface of the broad low hill north of the village is a sheet of wash ore. The roads north to Stormstown and west to Warrior Mark expose ore ground at the surface, on the slopes of the dry hollow in which the village stands, and to the north and south of the village. The old opening on the roadside 250 yards south of the village, is entirely filled up. Considerable quantities of very rich lump ore were taken out here many years ago, mostly from underground galleries. Much ore ground occupies the surface for more than 100 yards north-eastward. Limestone crops out 300 yards west of it dipping S. 30° E. $> 20^\circ$, and 300 yards north of it dipping S. 30° E. $> 18^\circ$.*

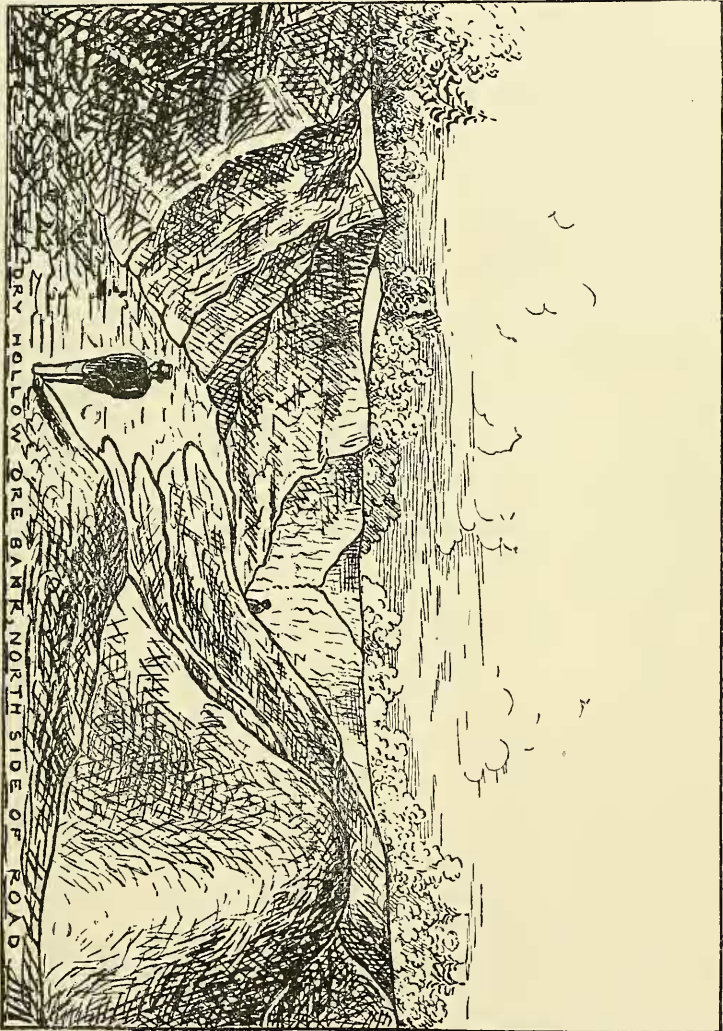
No. 19, Whorrel Bank, (see Local Map, fig. 17,) is a continuation south-west across Half Moon Run of the Gatesburg outcrop, which is here nearly 500 yards broad. The open cut on the north side of the Gatesburg road is about $40 \times 13 \times 5 = 2600$ cubic yards; that on the south side $30 \times 20 \times 3 = 1800$ cubic yards. Both have standing water in the bottom, and wash ore in the walls, while very heavy outcrops appear along the road, as well as along the cross-road leading up the ridge north to Lovetown, beyond which an old shaft has struck the underlying sand rocks.

The double excavation in fig. 10, $110 \times 40 \times 7 = 30,800$ cubic yards large, is separated by a stratum of limestone dipping S. 30° E., $> 26^\circ$, (one exposure looking like $> 50^\circ$,) the ore underlying, overlying and surrounding one end of it. The wash ore in the sidewalls does not look rich. It is reported that these holes were dry 40 feet deep and yielded good ore.

* The horizon of this and the Whorrel bank is still higher in the series than the last, as Section O D (fig. 3) will make evident.

The length of the surface show *i. e.*, S. W.—N. E. is only 50 yards, to be terminated by the erosion of Half Moon Creek Valley. The railroad is only 400 yards distant.

FIG. 28.



No. 20. Pond Bank, No. 2. is a small excavation $35 \times 10 \times 5 = 1750$ cubic yards, at the head of the hollow, or rather on the divide where the south branch of the long Dry Hollow proper begins to descend towards

Warrior's Run ; and along side of one of the summit cuts of the railroad. Good wash and lump ore show in the walls. No sandy ore is seen. The R. R. cut shows 10 feet of wash ore for a length of 100 yards. Altogether we have here say, 40,000 cubic yards of ore in sight.

No. 21. Wrye Bank. The local map, fig. 23, shows this extensive group of shafts commencing 450 yards northwest of the railway track, at an elevation of 40 feet above it, and continuing along the road up the slope to an elevation of 100 feet above the R. R., a distance of 400 yards. Over most of this surface the show amounts to little, proving how little we can rely on the surface indications as negative testimony. For, these works were extensively driven from 1852 to 1857, and yielded some very rich ore, while the surface showed only poor sandy ore.

There is one open cut, $25 \times 20 \times 10 = 5,000$ cubic yards large, showing wash ore in the walls from top to bottom, none of it rich, decidedly sandy, holding ironstained calc. sandstone masses, as at the east Pennington Banks. Very good open ore, bluish, and heavily charged with manganese occupied the west end of this open cut (Bocking). An old miner reports, that in the shafts they went through 26 feet of pretty worthless loose stuff and then worked 18 feet of good lump ore, without getting through ; that the shafts up the hill were dry ; those lower down quickly filled with water, and were therefore abandoned, one after the other, before they could get out more than 10 or 12 feet of lump ore. What the charcoal furnace miners called worthless is now valuable for hot blast, especially anthracite furnaces, and the whole of this great deposit will be washed and sold. The breadth of the belt of shafted ground is about 100 yards, but must be considered as indefinitely greater along the strike.

I am informed that in these old diggings the body of ore sank to 50 feet beneath the surface and thinned away, but came in thick again lower down, and approached the surface. Two good pillars are known to be left standing in the old works, under a top covering of sand, one at the lower end, the other at the upper end of the works. In the last, solid rich rock ore lies 45 feet beneath the surface. All the shafts are now caved in. The ore layers were traced for several hundred yards eastward by trial shafts.

The appearance of this ore differs from that of the Pond Bank No. 2 so much that we should suspect them to belong to a different geological horizon. This suspicion is almost confirmed by the general southeast dip of the outcropping rocks here and there exposed at the surface. This important structural question is clearly expressed by my Section C D (fig. 3), which passes through these banks. It is quite certain that the rocks which on dissolution delivered these ores, are the mother rocks also of the Kerr and Bredin, Hostler and Pennsylvania Furnace ores to be described hereafter. The great breadth of the Dry Hollow Outcrop belt corresponds with that of the localities just named, and I think it pretty evident that we have here two horizons of Lower Silurian ore-bearing limestones close together.

The old **Sandy Bank** is a group of small shallow pits, in very sandy

surface ore, but rich and good when washed, on the hill slope a few hundred yards northeast of the Wrye Bank, showing the continuation of the outcrop in the direction of Half Moon Run.

In the other direction, the outcrop has been exploited at the old **Pond Bank** of Bald Eagle Furnace, 500 yards southwest of Wrye Bank, and nearly in the bottom of the vale, which deepens rapidly.* It lies close to the foot of Hickory ridge; ore light but good, not sandy, and easy to smelt. A pond, dry in dry seasons, covers some of the old diggings. Much surface ore covers the neighborhood, and it will hereafter be an important mining ground, with heavy clay cover to the ore, requiring hard pumping.

Top ore of large size abounds around a sink-hole in Isaac Gano's fields, on the north slope of Hickory Ridge, a mile S. W. of the pond. The pieces seemed rolled from an outcrop of good ore seen half-way up the hill, in the Huntingdon Furnace woods.

At **Simpson's Bank** ($\frac{3}{4}$ mile further west) the wash-ore is good and easy to smelt. Whereas at **Andrew's Bank**, adjoining, (the Warrior's Mark and Pennsylvania Furnace Road separating them,) sandy ore only has been taken from the open cuts, but no shafting done.

Jos. Krider's fields are covered with very rich scattered pieces of ore, some lumps weighing 400 pounds. Attempts to find a bed at a little gap near by, have failed thus far. The shafts were tried in thick woods; others were too low on the hill slope, and encountered only wash ore. There is undoubtedly a heavy rock-ore deposit somewhere. Similar shows are again seen half a mile further on (west) opposite the old wash-machine, and Huntingdon Furnace has picked off the surface much of this loose block-ore. A small layer was found in two or three shafts, but never followed up to see what would come of it.

No. 22. Dixon's Banks are only a few small holes, fallen shut, with a slight sandy ore surface show, 100 yards west of the road, where it crosses the head of the middle branch of the Dry Hollow. Here "a small irregular vein yielded good ore a little west of it, on a detached knoll, a thicker vein of poorer, flinty ore was found, at the edge of a pond, and was thought not to pay for pumping, to get for charcoal furnace use.†

* This and the following named Banks are not exhibited on the Large Map, because not accurately located. Their descriptions I got from Mr. Böcking's notes.

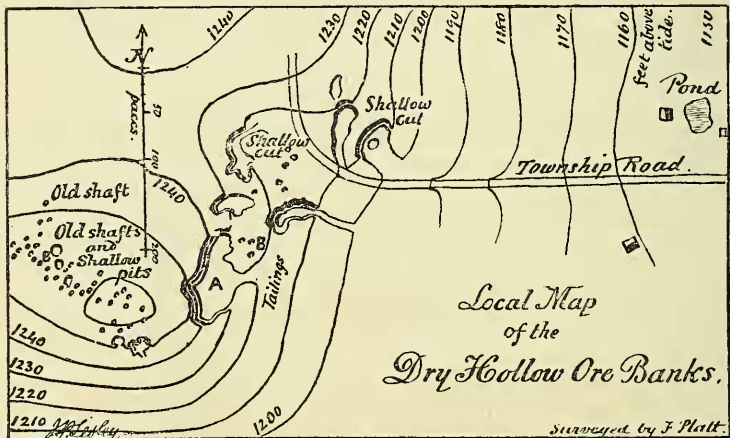
† Mr. Böcking thinks he remembers that this vein had a decided northern pitch, and distinguishes it thus from all the other veins of this range. This must be either a mistake or a mere local accident. Mr. Platt's field notes also mark a doubtful N. 30° W. $> 34^\circ$ dip of the limestones in the through-cut 240 yards northwest of Railroad section stake 81-80. But 100 yards N. E. of the same stake, soft rotten limestone strata dip S. 30° E. $> 20^\circ$. Other Railroad exposures show that the S. E. dip dominates the structure. Thus at Railroad station 4145, is a thorough-cut in blue limestone, dipping S. 30° E. $> 34^\circ$ with regular cleavage planes N. 60° W. $> 70^\circ$; at 4151, a good exposure of limestone gives S. 30° E. $> 26^\circ$. In Railroad cut at 4164, sandy and blue limestones the layers seem to dip S. 60° E. $> 31^\circ$; in the cut 180 yards S. W. of Railroad 4180 hard, sandy limestones dip S. 45° to 50° E. $> 26^\circ$.

The old Kelsey Bank yielded much good ore, years ago, in funnel shaped pockets, not continuous.

No. 23. Little Dry Hollow Banks (see Local Map, fig. 14) are near the crest of the low hill dividing the middle from the north branch of the Dry Hollow. No. 1, is a small hole on a small outcrop reported to have yielded six to eight feet of sandy lump-ore, soon running out. No. 2 consists of a group of small pits and trial shafts on a slight outcrop. Some ore was got from shafts A, B, and C. The appearances here are not favorable for future mining prospects.*

No. 24. The Dry Hollow Banks are the central figure in the broad expanse of outcrop which seems to fill the hollow and its three head branches, and to cover the dividing slopes, in many places if not continuously, north of the Railway. They are shown in map, fig. 29.

FIG. 29.



In the south-east corner of this map, the railroad curve ought to have been designated, the distance of the track from the principal excavation A, being less than 400 yards.

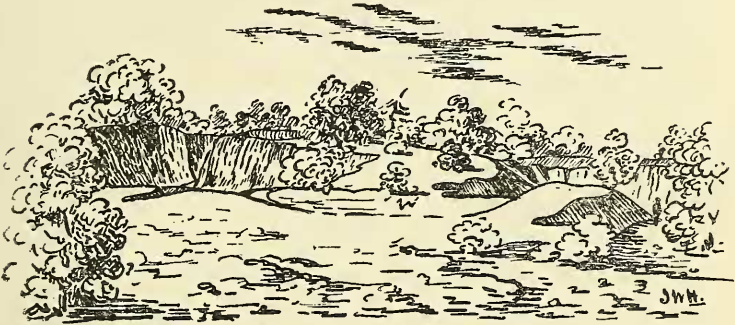
The cut on the south side of the township road is pictured by Mr. Harden, in fig. 28; that on the north of the road in fig. 30; and the road itself in fig. 31; the wash-ore in the R. R. cutting at the curve, south of the banks, is shown in fig. 32.

The Dry Hollow Bank, $\frac{1}{2}$ mile north of the R. R., $2\frac{1}{2}$ miles E. of

* Mr. Böcking reported some years ago that these works merely won small veins and top ore, while the body of ore is undoubtedly left under the little ponds, &c., at the foot of the hill. Good ore used to be raised from the Little Dry Hollow Bank, but efforts to "recover the vein" some few years ago failed, although the ore here rides to the top of the hill, where it is pipe-ore (as it also is pipe-ore on the northern side of the hill).

Warrior's Mark Village, is an extensive system of open cut excavations, from which great quantities of excellent ore have been got in past times. The term "system" is however inapplicable to the process of mining here employed, for it resembles rather the burrowing of animals. No

FIG. 30.

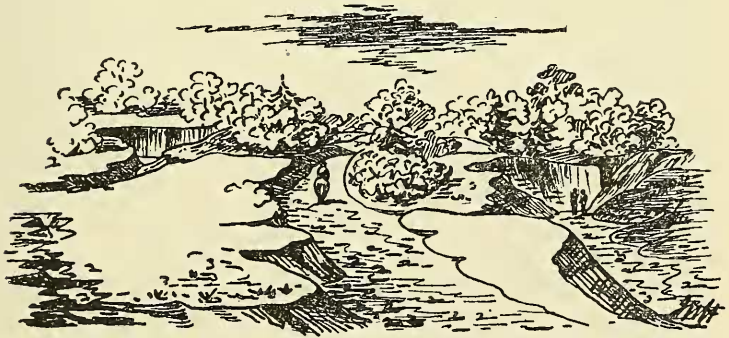


Part of Dry Hollow Bank. South side of Road.

one can estimate how much of the precious ore has been left untouched, for there are neither maps, nor records, nor traditions of the work.

The old miners merely say that the ore runs out against a bank of clay. But such reports are good for nothing; and even if literally true teach

FIG. 31.



Road to Warriors Mark through Dry Hollow Bank.

nothing, for they are sure to relate to single points, and fail of application at others. Fifteen years or so ago, some of the old pillars of ore were taken out by sinking shafts and driving short galleries at a few points. The ore is mostly wash-ore, that is fine ore disseminated through

clay. The dip is southward (towards the great central synclinal) and deep workings and powerful pumps are needed, in future, south of the old shallow surface workings.

From Dry Hollow Summit Cut for the Railroad to the first shafts, a distance of about 400 yards, there is a decided outcrop. The shafts extend over 200 yards to the edge of the big open cut A, fig. 29. They seem to have gone down* through wash and lump ore 60 feet to water, which in all cases stopped the works. The lumps alone were carried to the furnace. The wash-ore was not valued then ; now it is merchantable. The sinking was done at random and ore was always got.

Mr. Platt's estimates on the ground are as follows :

$110 \times 40 \times 10$	$=$	44,000	}	
$50 \times 15 \times 8$	$=$	6,000	}	76,000
$50 \times 15 \times 6$	$=$	4,550	}	cubic
$60 \times 25 \times 10$	$=$	15,000	}	yards of
$50 \times 10 \times 5$	$=$	2,500	}	excavation
$100 \times 10 \times 4$	$=$	4,000	}	done.

The main bank A, shows wash-ore of very variable richness from top to bottom, 50 feet. The shafts at B are reported 60 to 70 feet deep, through wash and lump ore. From shaft C, on the roadside, 60 feet deep, 1600 tons of excellent lump ore alone was selected for use.

About 300 yards north-east of the Banks, the railroad line has exposed a mass of lump and wash ore of excellent quality.

The Old Red Bank of Bald Eagle Furnace is on a continuation of the Dry Hollow deposit south-west, but higher up the hillside. It is shown in local map, fig. 19. Mining was confined to the surface ore which was sandy and without 'regular veins;' but no one knows how the deposit of ore is to the deep.

The surface show between the Dry Hollow Banks and the Red Bank is not so heavy as where the old excavations were made ; but the deposit underneath is really continuous and unbroken, as is shown by the cuttings through the ridge made by the railway between the two localities. See fig. 19.

Here wash ore has been exposed for 100 to 125 yards along the track ; sometimes 10 feet thick resting on clay ; sometimes 20 to 25 feet of wash ore holding larger lumps. The varying thickness of the red clay and ore layers in this cut is an instructive example of what the miners found in their shafts. Some of the lumps weigh 300 to 400 lbs. Very few pieces of silex appear ; and on the whole, this deposit looks freer from silica than any in the valley. Little or no soil covering exists.

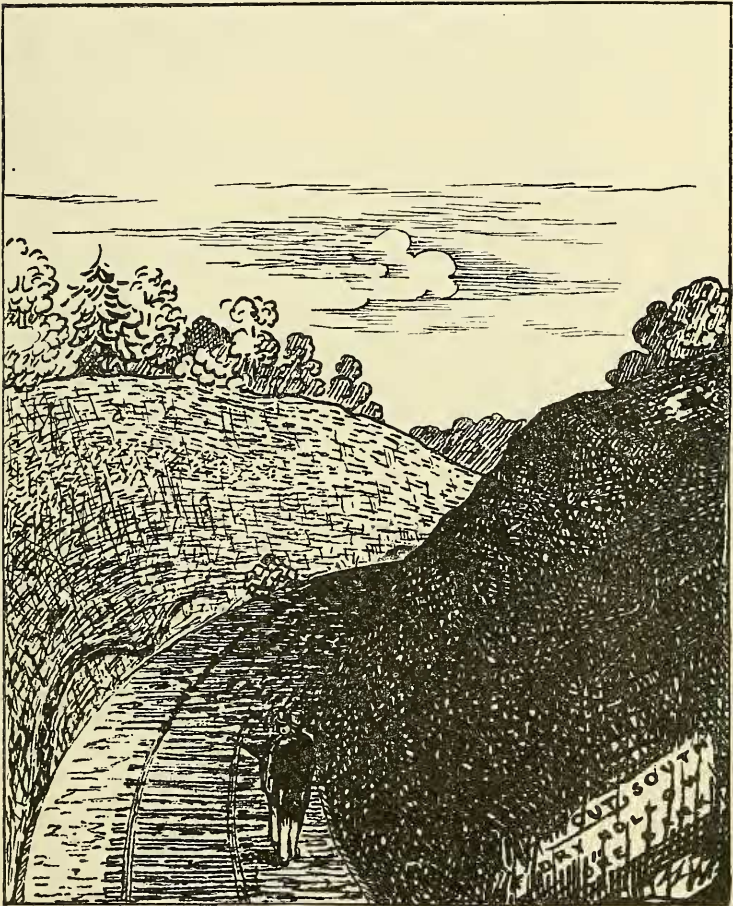
The Red Bank pits and shafts are very numerous, and all shallow. The ore when smelted alone, at Bald Eagle Furnace, made first class iron.

From the south-west end of the Red Bank to the north-east end of the Dry Hollow Bank is about 1000 yards. The breadth is 200 (say 150)

*25 years ago, more or less.

yards. The worked depth (to water) varies from 20 feet at Red Bank to 100 feet at Dry Hollow Bank. Taking an average of 10 yards, we have $1000 \times 150 \times 10 = 1,500,000$ cubic yards of wash and lump ore. Discard one-half of the leaner interval between, and allow one ton to the yard in consideration of the size and quantity of lump ore, and we have 750,000 tons.

FIG. 32.



In our ignorance of the condition of things where the water stopped the old fashioned rude mining, it is impossible to say how near this estimate approximates accuracy.

No. 25, Bean Bank lies a mile to the S. West of the Dry Hollow Bank, where many tons of surface lump ore were scratched out and

sent to Huntingdon Furnace ; as was done in other places along this part of the range on the South Slope of Dry Hollow Ridge. No attention was paid to the great body of wash ore forming the deposit, and no effort to mine to the deep. A vast body of ore-ground awaits future exploration and excavation, within a mile of the railroad. Quartz occurs in this ore bank.

No. 26, Bressler Bank, (see fig. 16) is a collection of small holes, on the north-west side of the ridge, in a ravine descending to the east branch of Warrior's Run, and distant from the railway, half a mile. About 2500 cubic yards of excavation seems to have been made in past years. The pits are fallen in, showing sandy wash ore in their sides. Eight feet of lump ore is reported as mined in this locality. No geological indications of the structure appear.

This completes all I have to say here of the Dry Hollow outcrop. For, although ore has been found further south-west along the south side of the ridge towards Warrior's Run, no mining has been done ; and the Old Seat Bank, (No. 37,) is so out of line with the Banks above described, that it may be left for notice in connection with the ores west of Warrior's Run. But I shall describe, further on, the continuation of this range where it crosses Warrior's Mark Run and at the Huntingdon Furnace and Dorsey Banks.

I pass over, therefore, to the Cale Hollow (Kerr & Bredin, Hostler and Pipe-ore) Banks further south-east.

THE CALE HOLLOW RANGE.

Cale Hollow is divided from Dry Hollow by Hickory Ridge, as shown in the Large Map ; and its ores lie in a deeper and narrower synclinal than the ores in the gentle and wide synclinal of the Dry Hollow as shown by section CD. They are, however, ores once carried by the same limestone strata, and ought therefore to be of the same general character. It is therefore remarkable that so little pipe ore has been found in Dry Hollow, while an abundance of pipe ore characterises the Cale Hollow Banks.

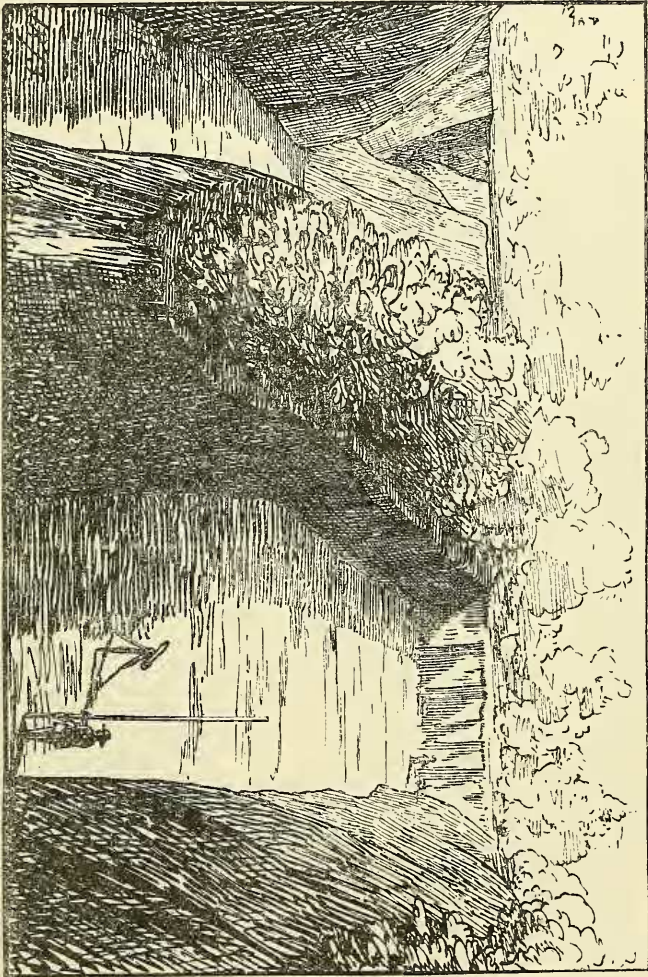
No. 27. Kerr & Bredin Bank, (see local map, fig. 24, and wood cuts 33, 34, 35,) is a small excavation of about 5000 cubic yards, showing in its walls lump and wash ore, 25 feet deep. Much of the wash ore seems leaner than in other Banks. A shaft has been sunk for exploration in the bottom of the old cut, and the report of it is favorable to future mining on a systematic scale. (See wood cut, fig. 35.)

The ore from this bank won for itself a high reputation at the furnace. It was called "gun metal ore," and was said to bear a striking resemblance to the Bloomfield ore of Morrison's Cove, south of Holidaysburg in

Blair Co., from which was made by preference the ordnance of the U. S. Army during the civil war

FIG. 33.

Part of the Kerr and Bredin Bank, sketched by J. W. Harder.



Dr. Genth's analysis of the Kerr & Bredin ore, given below, when compared with Dr. Otto Wuth's analysis of Bloomfield ore, made June 9, 1871, compare as follows :

	Kerr & Bredin.		Bloomfield.
Ferric Oxide.....	70.67	Perox. Iron	78.63
Manganese Oxide.....	0.36	Manganese	0.29
Cobaltic Oxide.....	trace		—
Alumina.....	3.91		2.50
Magnesia.....	0.26		0.38
Lime.....	trace		0.34
Phosphoric Acid.....	0.19		0.134
Silicic Acid.....	5.48		7.02
Quartz.....	6.80		—
Water.....	12.33		10.71

The extra quartz determined by Dr. Genth, diminishes the percentage of iron oxide in his specimens, and reduces the percentage of iron from 55.04 (Wuth) to 49.47 (Genth). Otherwise the ores are strikingly alike.

The **Kerr & Bredin** Bank lies at the foot of the south slope of Hickory Ridge, one mile W. N. W., of the Hostler Bank. In a dry autumn Mr. Bocking was directed to sink south of the old cut, and to mount a pump. He reported a 12 inch "vein of ore" at 40 feet, and water at 44 feet. A tunnel-way was commenced in the direction of the old cut, which caved in, and the works were stopped.

The continuation of these ores along the foot of Hickory Ridge, on the north side of Cale Hollow, is proven by a range of "lively outcroppings." In some places the surface is sufficiently rich wash-ore. One or two pits (Bronstetter's) were worked, for Huntingdon Furnace, $1\frac{1}{2}$ miles west of the Kerr & Bredin Bank, in "an irregular vein."

Northeastward the ores continue to show themselves to Half-moon Run, where "pipe-ore" is marked upon the large map. See Little Bank, below.

From a small cut at Eyer's, on the east side of Half-Moon Run, pipe-ore was raised many years ago. The limestone rocks at Eyer's house, 100 yards south of the spot, dip to the S. 30° , E. $> 21^{\circ}$.

Another old pipe-ore locality shows now fair ore on the surface, near two small trial pits.

No. 28. Hostler Bank (see local map, fig. 26, and wood-cut fig. 36).

This excavation occupies the northern slope of the Spruce Creek anticlinal ridge, as a large open cut, from which the ore was in old times hauled to Pennsylvania Furnace, two miles due east of it.

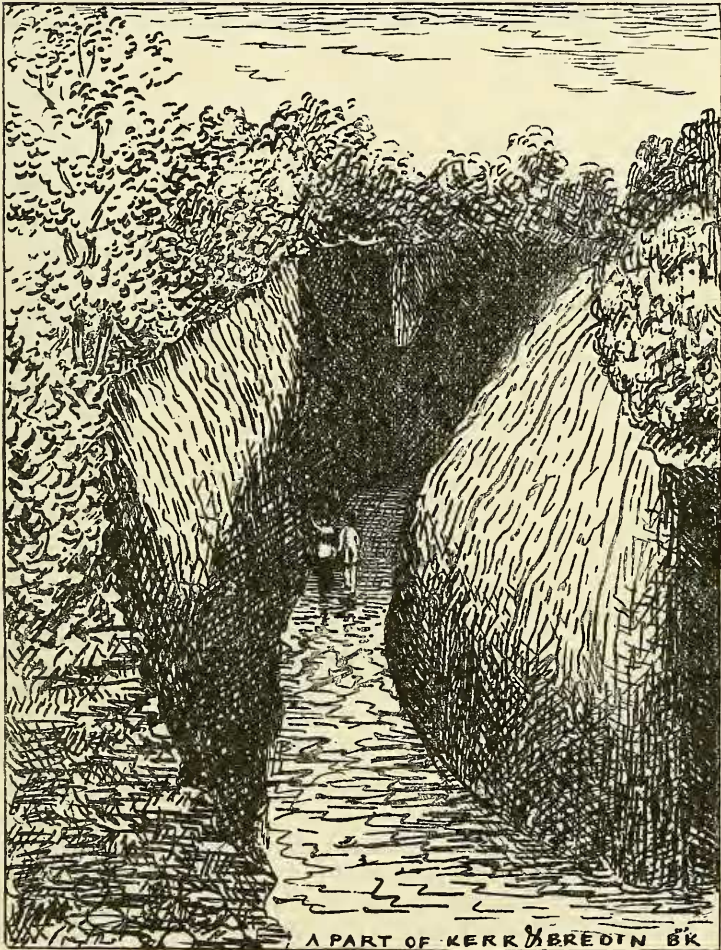
The recorded history of this important mine reveals the following features. Wherever the diggings were made they went down through "pipe" wash-ore which was occasionally mixed with lump-ore, to depths of 60 and 65 feet, in all the shafts.

One of these shafts passed through this wash-ore 65 feet, and then passed through a stratum of solid limerock, varying in thickness from 10 inches to 2 feet. Below this limestone lay lump "pipe" ore, into which

the shaft was sunk 6 feet further and then the flow of water stopped its further descent.

From the bottom of the shaft a five inch auger hole was then drilled through a continuous bed of pipe ore to an additional depth of 39 feet.

FIG. 34.



The percentage of iron in the pipe ore is uniform; or varied only by the chemist's including in his analysis adherent or enclosed clay.

It is a constant feature of the Pipe ore banks of the southern range that they do not furnish the "lean ores," so-called, which are met with

in the Banks opened along the more northerly and geologically lower outcrops of the "Barrens" in this valley. It has been the uniform experience at the Pennsylvania, Hostler, and other Pipe ore banks that shafts and borings have always passed through lump-ore, after having been sunk or drilled below water level. But as pumping apparatus on a sufficient scale has never been applied to such deep shafts and borings, they have in no case passed through the deposit of lump ore, the thickness of which is therefore still a matter of conjecture.

I give the history of these operations as an evidence of the insufficient extent to which the development of this iron-ore district has been carried; to show that only its surface has been scratched, but its deposits not mined. Regular, systematic, efficient operations are yet to be begun. They await the completion of the railroad and that demand for large quantities of ore from distant furnaces which is already become so urgent. The underground drainage all through the Valley is immense, and the largest bodies of ore, and especially of pipe-ore, can only be won with heavy pumping and systematic stoping.

The Hostler open-cut Bank must be sunk in air to the lower ores, and through them to the bottom floor of all; then with powerful pumps to keep the water down, the clay stripping above can be washed, and the heavy face of ore below can be stoped and the top stuff thrown back into the abandoned ground as the ore-face advances. As Mr. Bocking justly remarks, "35 feet of ore will well pay for stripping 65 to 75 feet" of clays above it. He adds, and I agree with him heartily: "The time for shallow digging and ground-hogging is pretty well past in these barrens, and the exploration of the richer banks may require in future preparations that will take some capital, and may need in some cases two or more years before yielding a return."

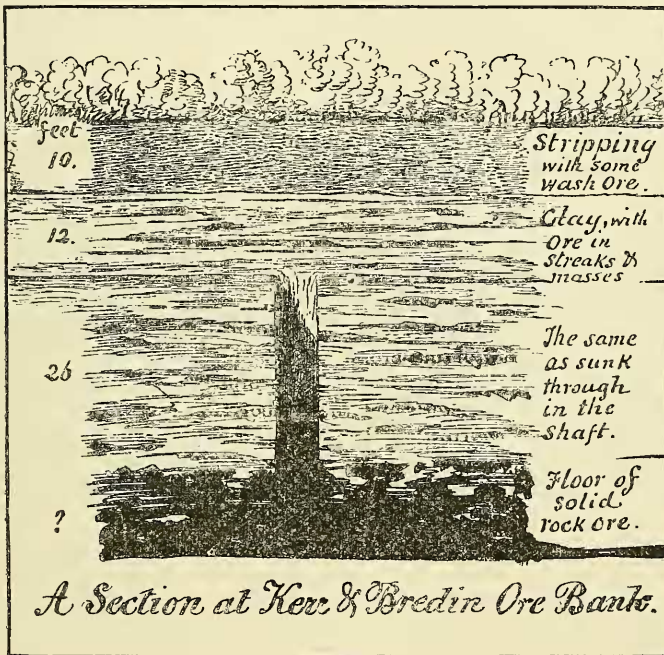
The Hostler Bank excavations measure about $120 \times 50 \times 10 = 60,000$ cubic yards. The ore lies like that to be described in Pennsylvania Furnace Banks, as a mass of clay and wash-ore separated by ribs of undecomposed limestone. The walls are about 30 feet high, but the high northwest dip of the measures prevents this figure from being used as a datum of calculation. It only shows in a general way the depth below the sod to which the weathering action had gone, *as exposed by the miners*. The late sunk shafts passed alternate soft beds of ore and hard ribs of limestone, all on a steep dip; 38° to the N. 35° W. In a shaft at the northwest end of the open cut one shaft went down through 75 feet of wash-ore ground before striking the solid limestone rocks and water.

It is impossible from such data to estimate the future yield at this locality, but the amount of ore to be won must be very great. Nor is it confined to the neighborhood of the old works. The ore-belt runs on southwestward for at least five miles.

At the distance of 1,900 feet there are somewhat less than twenty old shafts in one group, quite forgotten until recently discovered by Mr. George Lyon. They were mostly shallow pits in the surface of the pipe-ore bearing clays; but some of them look as if they had been sunk to a considerable depth; and their number proves that the search for ore was remunerative even at that day.

This part of Cale Hollow is a wide, flat, slightly undulating, dry vale, every part of which shows a top-dressing of fine ore. It is a virgin district. Mr. Lyon suuk one trial-shaft in it, and struck an "ore-

FIG. 35.



vein." There was a similar accidental discovery of another group of five or six pits from which some top-ore had been scraped. I have no doubt that a continuous belt of mining ground runs the entire length of Cale Hollow.

The Red Bank, $1\frac{1}{2}$ miles from the Hostler, on the same slope of the Spruce Creek Ridge, is old and disused, the ore in the top clays was stripped, but no attempt at deep mining was made. Another old bank in line with it, but across a little ravine issuing from the ridge, furnished some pipe-ore to Huntingdon Furnace. Still further west,* in a similarly

* $4\frac{1}{2}$ miles from Hostler Bank.

situated bank, near Huntingdon Furnace, a vein of good, red-short ore was struck, and abandoned on account of water. On working one part of this pit the ore became too sulphureous to use. It will be again referred to after describing Bank No. 29.

The belt of Cale Hollow Ores may be traced northeastward with the same general character.

Little Bank, for instance, lies two-thirds of a mile northeast (near the Warrior Mark Pennsylvania Furnace Road), $1\frac{2}{3}$ miles west of Pennsylvania Furnace. Here very rich top-washings cover a high flat area connected with Hickory Ridge. Seams of the ore penetrated the limestone rocks all the way down a 40 feet shaft, under which the main body of ore dips northward.

The **Eyer Bank** (already mentioned) is an old excavation one mile still further east, on the east side of Half-Moon Run.

Going on northeastward across a dividing ridge, the ore appears again along Tadpole Run, in Sleepy Hollow, and at the head of the Beaver-dams, for a distance of more than a mile. Years ago, some pipe-ore was raised, for Centre Furnace, east of B. Crane's, but the surface was merely scratched. At the Pennsylvania Furnace old surface-pits, sunk at the beaver-dams, the body of ore probably lies under the bed of the run and would require heavy pumping.

The "dry hollow" which carries the Valley of Tadpole Run on in a straight line northeastward, and is a geological prolongation of Cale Hollow shows plenty of out-croppings of ore, just as Cale Hollow does, and the ore is of the same kind—pipe-ore. In fact the ore belt continues to McAllister's and the School House cross-roads, eight miles northeast of the Hostler Bank, and far beyond the limits of my large map.

Between McAllister's and Pinegrove Mills, the country spreads out into a plateau two or three miles wide, through which runs the Brush Valley Anticlinal. Here, far beyond the east limit of my map, are the

Old Weaver Banks; two open-cuts and several shafts near them, abandoned years ago. No systematic mining was attempted in that early day, the work being done by the farmers. Tradition speaks of "ore veins" being reached, but probably too well watered for the natives to cope with them. "The ore lying around the holes is not a regular pipe-ore, but is mixed with liver-colored ore, and reported red-short." We have here, then, ores not belonging to the Hostler and Pennsylvania Pipe-Ore Bank system connected with the sandstones of the anticlinal, that is, ores belonging to the underlying limestone.

SPRUCE CREEK RANGE.

No. 29, Pennsylvania Furnace Ore Bank. For about fifty-eight (58) years Pennsylvania Furnace has been supplied with its stock from the extensive excavations on the gently-sloping south side of the anti-

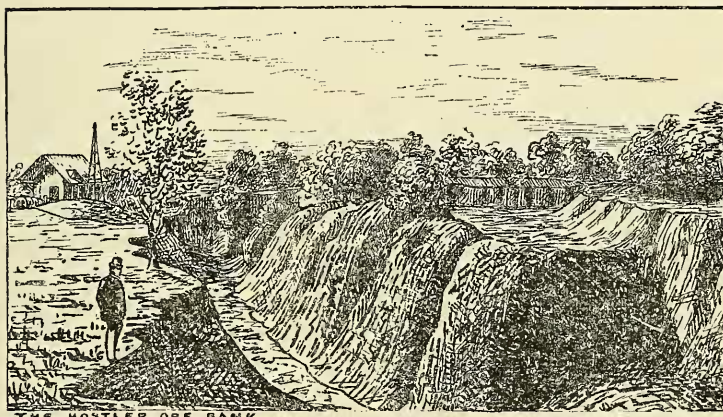
clinal ridge facing Tussey Mountain ; Spruce Creek, above the Furnace, flowing between the ridge and the mountain.

See local map, fig. 37, in lieu of further description ; and the landscape sketches of the excavations, to illustrate their extent and character : figures 39, 40, 41, 42, 43.

The geologist can here study the theory of the formation of the Lower Silurian Brown-Hematite ores of Pennsylvania to great advantage. I know no better place, and few so good.

The ores are evidently not washings from a distance ; neither from Tussey Mountain, nor from the present surface of the anticlinal ridge ; nor from any formerly existing surface in past geological ages, when the surface stood at a much higher elevation above sea level. They are evidently and visibly interstratified with the soft clay and solid limestone

FIG. 36.



THE HOSTLER ORE BANK

layers, and obey the strike and dip of the country ; the strike being along the valley, and the dip about 40° towards the southeast.

Thousands of minor irregularities prevail ; the streaks of ore and masses of clay, are wrinkled and bunched, and thin out and thicken again in various directions. But all this irregularity is owing to the chemical changes of the strata, and to the changes in bulk of the different layers during the protracted process of solution and dissolution, during which the looser calciferous and ferriferous sandstone layers have lost their lime constituent, packed their sand and clay more solidly, and perhydrated their iron. In this long process cleavage-planes have been widened into crevices ; caverns have been excavated ; pools or vats have been created ; precipitates of massive (rock and pipe) ore have been thrown down ; and a general creeping and wrinkling of the country been effected. But the original general arrangement or stratification has been preserved ; and those portions of the whole formation, which had but little lime, have

been left standing as sandstone strata ; while others having but little sand remain as solid and massive limestone strata ; those which had an excess of alumina are now in the condition of streaks, masses, or layers of white or mottled clays ; and only such as were properly constituted clay-sand-lime-iron deposits originally have so completely dissolved as to permit the lime to flow off, and the iron to consolidate into ore.

Every stage of this interesting operation, and every phase which it presents in other parts of the Appalachian belt of the United States, from Canada to Alabama, may be seen and studied in these old and extensive ore banks of Pennsylvania Furnace.

At first sight of the bank the ore deposit looks as if it were a grand wash or swash of mingled clay and fine and coarse ore grains and balls, occupying hollows, caverns and crevices in the surface of the earth and between the solid limestone rock ; and some of it undoubtedly has been thus carried down into the enlarged cleavage partings of the limestones ; and into sink holes and caverns formed by water courses ; where it now lies, or lay when excavated, banked up against walls or faces of the undecomposed lime rocks. But as a whole the ore streaks and "main vein" of ore must occupy nearly the same position originally occupied by the more ferruginous strata after they had got their dip and strike. See fig. 40.

The ore is taken out with the clay, and hauled up an incline, by means of a stationary steam engine at its head, and dumped into a large washing machine, with revolving screens ; whence after the flints and sand stones have been picked out, it is carried on an ironed tramway, to the bridge house of the Furnace. See fig. 43.

The ore forms from 10 to 50 per cent. of the mass excavated, and the small amount of handling makes the ore cheap.

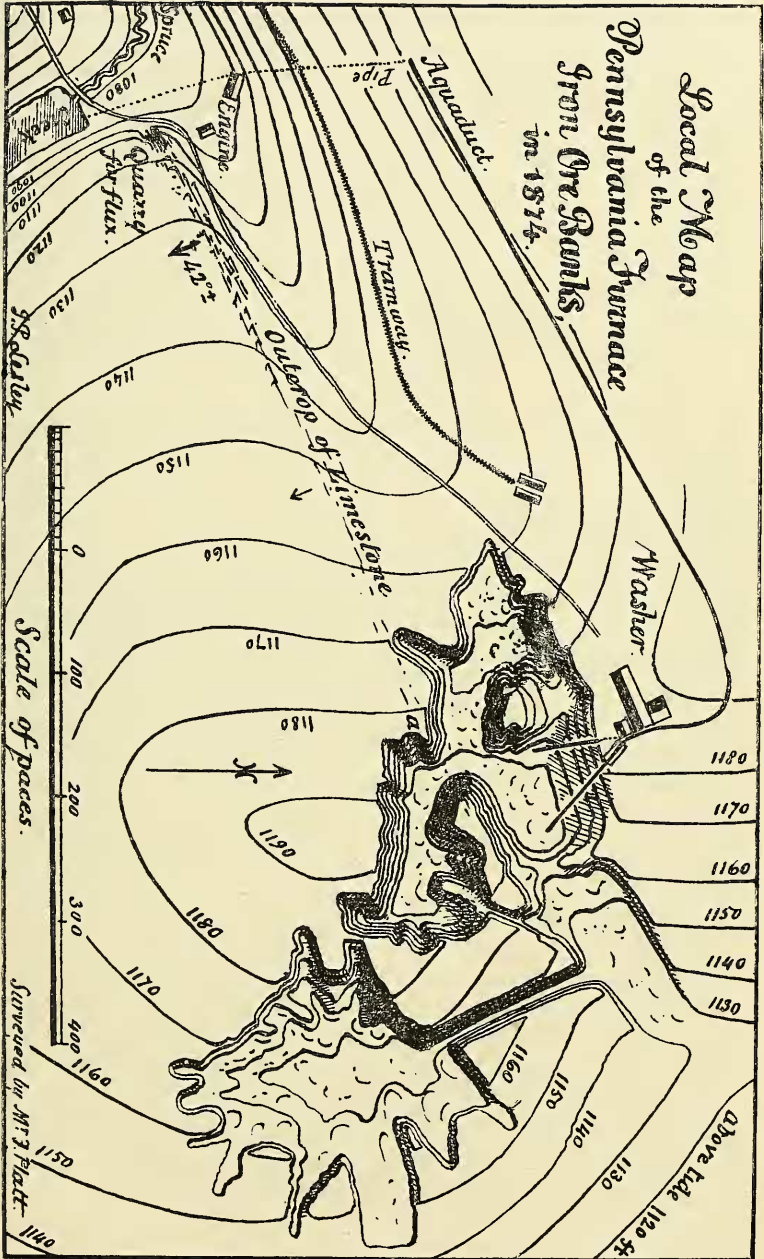
The floor of the excavation is about sixty (60) feet below the level of the wash machine.

Shafts sunk from 30 to 35 feet deeper, in the floor, to a permanent water level, have shown that other and even better ore deposits underlie the workings, covered by the slanting undecomposed lime rocks. This is an additional demonstration of the correctness of the theory above stated.

The upper ores will furnish stock for yet many years. After that, or in case more furnaces be erected, or distant markets call for the shipment of ore by railway, deep shafts or bore holes must be sunk to drain the underground, and the lower ores may then be lifted to an extent which can hardly be estimated now.

The prism of ore *in sight*, technically speaking, if calculated roughly from the areas exposed by the old and new open cuts, and by shafts sunk at various times and in various parts of the floor, gives several millions of wash-ore, lump-ore and pipe or rock ore. Thus taking the area exposed at say 550×450 yards, and the depth at only 15 yards, we have 3,612,500 cubic yards, which on washing would yield 602,000 tons of prepared ore.

FIG. 37.

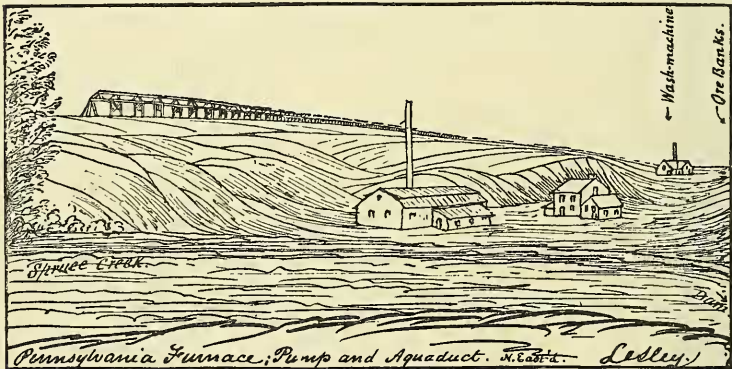


Of this, about 100,000 tons have been passed through the furnace, yielding nearly 50,000 tons of neutral cold blast charcoal iron of the best quality, leaving 500,000 tons of ore to be excavated.

But this is only a portion of the deposit; for the ore ranges away beyond the high walls of the open cuts into the surrounding land an unknown distance. The large area stripped last year towards the northeast shows how extensive the deposit is in that direction.

Add to this the great depths to which the ore is known to descend, and it seems to me certain that a million of tons is as probable an estimate as a half a million. Large quantities of ore are left standing between the hard limestone ledges exhibited in figure 40 (taken from *a* in local map fig. 38), and in figure 34, which is an enlarged view of the sharp promontory seen in fig. 33, sketched to show its geological structure. The dip of these limestones is to the S. 35° , E. $> 35^{\circ}$ to 40° ; and they are exactly on range with the limestone outcrop along the road, at the quarry, and

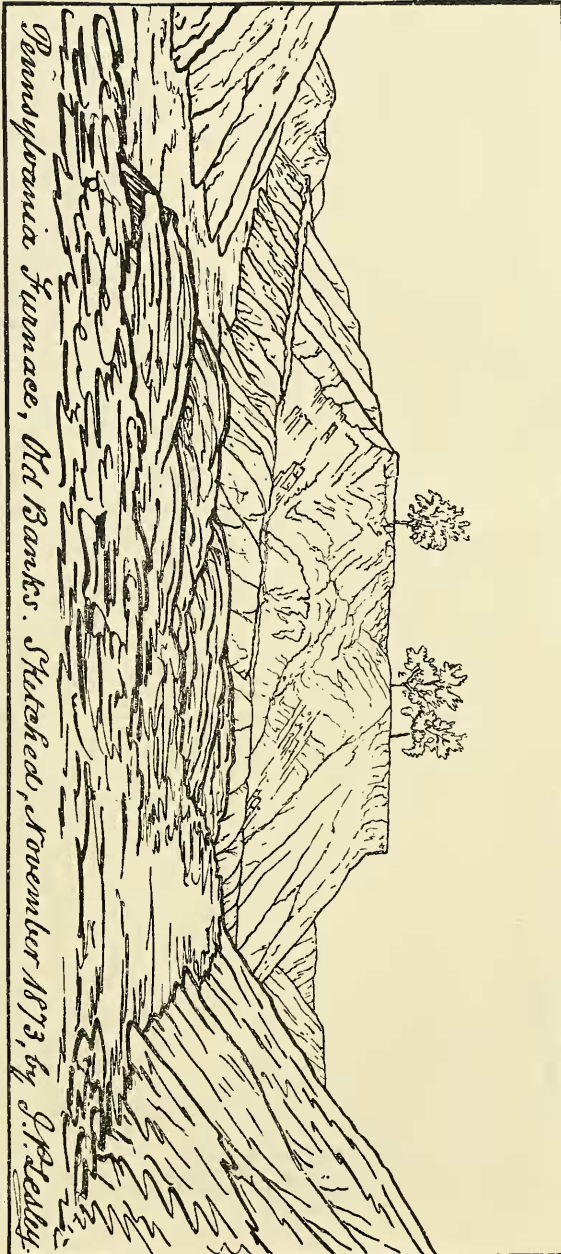
FIG. 38.



past the Furnace, as shown in fig. 37. Slight crumplings of the limestone vary the dip from 18° to 65° ; but these are due either to movements in the yielding ore mass or to a deception caused by mistaking cleavage planes for bed plates. No such variations are apparent at a distance from the banks, the whole limestone formation descending uniformly beneath the foot of Tussey Mountain with a dip of something under 40° .

The pictures figs. 41 and 42 are views of the deep cut looking east from *a* in local map fig. 37. The view in fig. 43 is taken looking northward into the main ore bank, from near *a*; and it shows the new incline, the washing house, and the ridge above it, along the crest of which the aqueduct is carried on tressels, for 2000 feet. Fig. 38 shows the end of the aqueduct where it is mounted by the pipe leading up the hill-side from the double Worthington pump in the engine-house, fed by another pipe from the dam. Behind the hill seen in fig. 43, in a hollow on a level with the northeast end of the banks, is the settling-dam.

FIG. 39.



Pennsylvanian Furnace, Mt Banks. Sketched, November 1873, by J. P. Lesley.

The height of the walls of the various excavations may be seen by reference to the ten foot contour lines in fig. 37. These also show that the ground now so deeply excavated once formed a high divide between a vale descending southwest to Spruce Creek, and a corresponding but shallower vale descending northeast to the settling-dam hollow. It looks as if the ore once filled both these vales, but has been excavated by the natural drainage into Spruce Creek, from the one which descends in that direction, and, perhaps from the valley of Spruce Creek itself, down to and beyond the Furnace.

The entire walls of the cuts are of wash ore, and it is all torn down and taken to the washing machine. But the tops of pyramids of solid pipe ore are exposed in the floor, and some reached to, or nearly to the sod above. At one of the deepest places in the floor, 60 feet below the sod a shaft was sunk 40 feet further through solid pipe ore, and then limestone, and was stopped by water. Water does not stand in the present floors on account of the free circulation, at a still lower depth, through crevices and caverns communicating with Spruce Creek, which itself issues from a cave.

The books at the Furnace show as an average for some years, 6 tons of wash ore to 1 ton of ore; 2 tons 1 cwt. of ore to 1 ton of iron; and \$2.25 per ton of ore delivered at the Furnace, represents the cost of mining, inclusive of all expenses.

I shall give in an appendix, the opinion of Mr. Harden on some practical points which I requested him to study, for which purpose he visited some of the Banks described above.

Outcroppings of ore occur east and west of the Pennsylvania Furnace Banks on the southern slope of the anticlinal ridge facing Spruce Creek and the Tussey Mountain; but no excavations have been made, because sufficient stock was always procurable at the Banks near the Furnace. It is not to be supposed, therefore, that equally large and important deposits may not be exposed by future systematic mining operations, when the completed railway shall make demands on this ore belt for supplying the furnaces of Eastern and Western Pennsylvania.

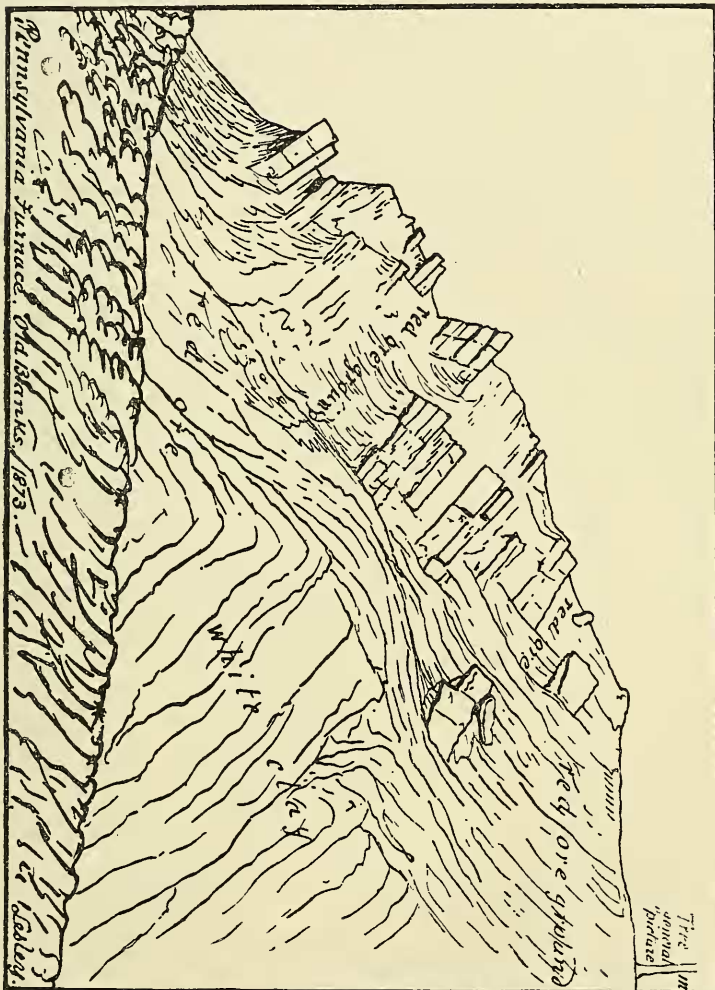
Some of these surface-shows of ore are near the top, others near the bottom of the hill slope. The ore surface is commonly high up on the slope, or on the flat rolling back of the anticlinal ridge.

John Ross has in his fields, north of Pinegrove Mills, (miles east of Pennsylvania Furnace,) an old funnel shaped hole, from which very rich pipe ore was taken, and more can be seen in its sides, but no surface-show; and I have no data on which to base an estimate of quantity. The ore was sent to Monroe Furnace; was rich; but very red short: lumps of pyrites being visible in the bombshell ore lying about the hole; which is also coated with white sulphates.

Surface ore can be traced all the way from Ross' to Pennsylvania Furnace, but no search underground seems ever to have been made or called for.

In the other direction, down Spruce Creek, south-west of the Furnace, a few outcroppings on the surface appear, but lie neglected for the same reason. A few trial-pits seem to have been sunk near the school house,

FIG. 40.



and near Mr. Geo. Lyon's mansion, south of the turnpike. Large pieces of pipe ore lie in the east corner of Mr. Thos. Lyon's fields, at the foot of Tussey Mountain. Ore has also been noticed in Mr. Stewart Lyon's north fields.

All the above are on the south slope of the anticlinal of Brush Valley, facing Tussey Mountain. The anticlinal may be studied where the limestone rocks are seen dipping both ways (N. W. and S. E.) in the end of the hill at the Furnace, and in the railway rock-cuts as the line makes its semicircle down Half Moon Run and up Spruce Creek and Tadpole Run.

Three miles further down Spruce Run a pipe ore bank was commenced on the south slope of the Anticlinal, to supply works erected at the mouth of Spruce Creek, for a patent process to convert the ore directly into wrought iron; but the patent process failed and the mine was never worked. It sufficed to show that the ore belt or outcrop follows the ridge along the north side of Spruce Creek towards the Juniata, but coalesces with that of the Cale Hollow, or north dip, beyond Huntingdon Furnace, and sinks beneath the surface, for no trace of it is found in the Little Juniata River section, where the Canoe Valley anticlinal may be seen replacing this of Brush Valley.

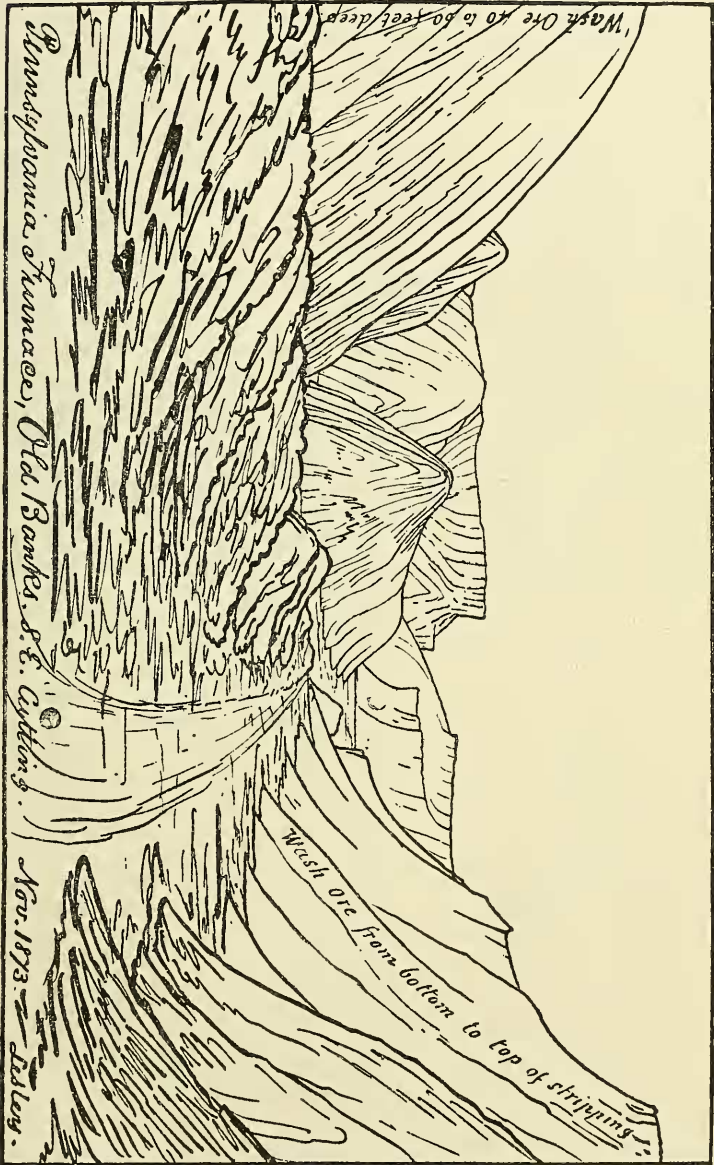
Returning thus to Warrior's Mark Run, and the neighborhood of Huntingdon Furnace, I have little to add to finish this report, except concerning an ore belt, west of the Run, on the south slope of the ridge in line with the Dry Hollow Banks. But before speaking of it, I shall give the following section up Warrior's Mark Run :—

At the mouth of Cale Hollow, in the north dipping rocks of the Spruce Creek Ridge anticlinal, and 150 yards east of the mill-dam, or a mile east of Huntingdon Furnace, there is marked on the map an old pipe-ore bank, now fallen in. Lime rocks here dip N. 30° W. $> 50^{\circ}$; but, by the road-side, 300 yards to the west-southwest only 38° ; and in the hill-side, 650 yards to the west-northwest, 12° in the other direction S. 30° E. The Old Seat Bank, No. 30, is 1,100 yards distant (up Warrior's Run towards the N. N. W.) from this old bank. The Cale Hollow is thus seen to be synclinal, and, allowing for the different strength of dips observed there can be no reasonable doubt that the same ferriferous limerocks out-cropping here outcrop also at the Old Seat Bank; and I have so drawn the Section A.B.

The ore at this old bank is reported to have been extraordinarily charged with sulphur; but I could not learn exactly in what form.

No. 30. The Old Seat Bank, on the east bank of Warrior's Run, $2\frac{1}{2}$ miles below where the railway crosses the run (at Warrior's Mark), is an old open cut with ore in its floor, abandoned many years ago for want of pumping machinery of adequate power. What little liver-colored ore is visible, looks lean, and much flint lies about. The area of the cut may be 4000 square yards. Water stands in it to within 10 or 12 feet of the top. It has been worked to a depth of 40 feet. About 30,000 cubic yards of ore-ground has been taken out. Although much liver colored ore like Pennington ore lies about, no pieces of sandstone are visible; but a good deal of flint is among the ore, as at Pennsylvania Furnace Bank. Not much surface-ore shows in the neighborhood.

In the gap of the Dry Hollow Ridge, six hundred yards higher up the
FIG. 41.



run, limerocks crop out, dipping also S. 30° E. > 9°; and 300 yards fur-

ther, sandy limestones, S. 30° E. $> 10^{\circ}$. 500 yards further up the run, pipe-ore is reported, ploughed up in the fields. This belongs to an ore-bearing strata about 700 feet lower in the formation than the ore horizon at the Old Seat Bank. The dip is continuous and equable; there can be no mistake. 500 hundred yards still further up the run, at the forks of the road, still lower sandy limerocks are seen dipping the same way, S. 30° E. $> 13^{\circ}$. Other exposures occur in this interval dipping also S. 30° E. $> 13^{\circ}$. No dips are noticed in the next 1000 yards, to the toll-gate and cross-roads and forks of the Creek; but there is no reason no doubt that a southeast dip fills the interval, becoming ever more gentle.

Five hundred yards southwest from the toll-gate, and 50 yards off the road (towards the northwest) on land 70 feet above the water, is an old deserted pipe ore bank 50×10 yards. This lies just 1000 yards due northwest of the pipe ore last mentioned as ploughed up in the fields; and if a continuous southeast dip of 10° be *supposed*, we should find in it an evidence of a third and still lower pipe ore horizon, 550 feet below the second and 1250 feet below the first, or Old Seat ore horizon. But it would be very unsafe to consider this the simple state of the case. The place where ore was "ploughed up over a space of 600 yards" is worthy of a thorough investigation, but the surface show is slight. The other locality where lumps and pipes of solid ore were got 25 years ago from the open cut and underground works, is reported to be rich still. None of its wash ore was taken away.

This place is very important. It proves conclusively that pipe ores occupy a *geological* range of at least 1250 feet of the Lower Silurian Formation. And these exhibitions on Warrior's Run connect the rich Dry Hollow Group of Banks already described, with the Huntingdon Furnace and Dorsey Group next to be described.

The toll-gate is only 800 yards down the run from where the railway crosses it. And the southeast dipping Beck and Town Bank ores (Nos. 4 and 5) are only 400 yards further up. The Beck and Town ore horizon therefore underlies the toll-gate ore rocks (unless there be some concealed disturbance in the interval), at a *geological* depth of at least 1200 feet, and probably 1500 feet. For there are 20° dips (to the southeast) in the railway cut, and 35° dips in Warrior's Mark Village. If I am anywhere near the truth, the Pennington Range ore horizon (Becks, Town, &c.) underlies the Cale Hollow Pipe Ore horizon at a *geological* depth of 2500 to 3000 feet; which may well explain their different qualities. And this result is in harmony with features of my cross-sections AB and CD.*

* The Pennington and Lovetown ores being on the same geological horizon, and there being a breadth of limestone outcrop (dipping S. 30° E. $> 50^{\circ}$), between Lovetown and the Bellefonte fault at the foot of Bald Eagle Mountain, at least 700 yards broad, we have about 5000 feet of Lower Silurian measures visibly exposed underneath the Cale Hollow (= Pennsylvania Furnace Bank) ore horizon. Adding to this the 2500 feet of limestones between Pennsylvania Furnace bank and the foot of Tussey, and we have a total thickness of Lower Silurian Limestones from the bottom of No. 111 (the Hudson River Slate) down to the jaw of the Bellefonte Fault, of 7750 feet; a very great thickness; but quite in harmony with all that we know of the Trenton, Black River, Bird's Eye, Chazy and Calceiferous in the Great Valley of Reading, Harrisburg, Chambersburg, Winchester and Knoxville. This, so far as I know, is the first approximately accurate measurement of these formations in mass south of their New York outcrops, which are very thin in comparison with these.

No. 31, Huntingdon Furnace Banks. These lie along the southerly slope of a prolongation of Dry Hollow Ridge, west of Warrior's

FIG. 42.



Run, and within a circle swept around Huntingdon Furnace with a radius of two miles, as shown on the land-map. The Dorsey Banks are outside

this circle, but are excavated in the same belt of outcrop. The outcrop is very broad because, as we have just seen along Warrior's Run, the southeast dip is very gentle, about 10° . This has allowed a very large dissolution of the ore-bearing rocks.

The **Wilson Bank** is two miles west of Warrior's Run; no ore has been found in this interval, the slopes being sandy. Here limestone begins to come in, overlying the sandstone, and ore-bearing clays take possession of the surface. This sandstone has been mistaken for the Calciferous Sandrock; but must be one of the numerous intercalations of sand in the great limestone series.

The **Keefer Banks** follow, in the next half mile, and, although exhausted as to the wash ore of the outcrop, can be mined to the deep if proper pumping apparatus be mounted to keep the underground water down.

Fig. 44 gives a local map of these excavations, which severally measure, as they come in order along the line of Mr. Platt's survey:—

a.	*	130	×	30	×	8	=	31,200	cubic yards.
b.	*	160	×	35	×	8	=	44,800	“
c.	†	40	×	25	×	10	=	10,000	“
d.	‡	120	×	40	×	8	=	38,400	“
e.	§	100	×	40	×	8	=	32,000	“
f.	§	30	×	30	×	5	=	4,500	“

Total excavation, say, 161,000 cubic yards.

No. 32, Dorsey Banks, see fig. 44.

These works lie just outside the two mile circle around Huntingdon Furnace Stack (see Land-line Map), and are used for Barre Forge, distant three miles due west on the Little Juniata River; the nearest distance to the river by the Township line in a southwest direction being two miles.

There is first an open cut on the south side of the road, see fig. 44, measuring $65 \times 25 \times 6 = 9,750$ cubic yards of excavation, with wash ore in the walls. Then, a shallow open cut, ten or twelve feet deep, $75 \times 30 \times 4 = 9,000$ cubic yards, the floor being everywhere wash ore.

The Main Bank, in the southwest corner of fig. 44, is divided by a slide of the southeast wall into two open cuts, $200 \times 70 \times 15 = 210,000$ cubic yards, with wash ore walls and floor (now generally 30 feet deep), but excavations have been made much deeper.

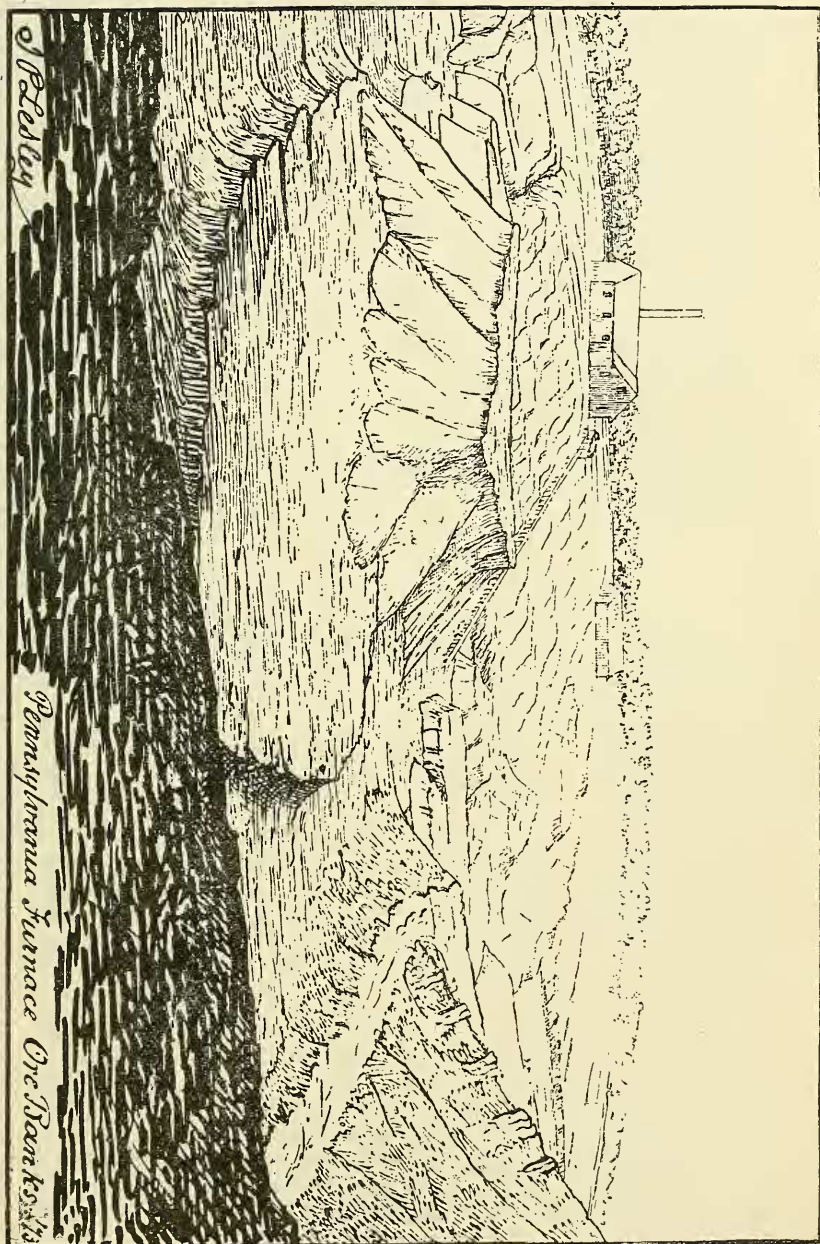
* These lie south of the road, on the large map. Eight yards is taken as the average depth of both, but they may have been worked deeper. Wash ore forms the walls.

† Also south of the road and beyond the limits of fig. 44.

‡ North of the road, at the northeast corner of fig. 44. It has not been worked for years. Wash ore forms the walls.

§ North of the road, and of the Dorsey Bank, fig. 44. Both have fallen shut. Wash ore forms the walls.

FIG. 43.



From the northeastermost Huntingdon Furnace Diggings to the last Dorsey Digging is a stretch of about 2000 yards, with ore shows filling up the intervals between the banks. There is a maximum breadth of 500 yards. But if half that be adopted for an estimate, we have an area of wash ore here equal to 100,000 square yards, in all respects like that of the Dry Hollow Bank district (on the same range) described above, and representing, at least, one or two millions of cubic yards of ore ground, besides whatever deeper deposits of pipe ore exist.

As in Dry Hollow, so here much lean ore is mingled with the rich, and much dead stripping will be required in places.

There is this distinction: the ore of the barrens, that is the liver-colored and more sandy ore ranges along the northwestern side of the belt of outcrop, up the hill-side; pipe ore characterises the down hill, or southeastern side of the outcrop. The main bank is wholly in the top or wash ore covering, and has merely revealed the principal deposit of rich rock ore and pipe underlying it. Those who worked the pit describe a layer of ore 6 to 8 feet thick as apparently creeping downhill, overturned, and covering itself. What this description means I do not know. The ore makes excellent iron.

It is unnecessary for me to say that the ferriferous limestones described in the above details, and crossing the river (S. W.) into Sinking Valley, carry the ore ground outcrops with them, and that these have been mined to some extent at various places south of Barre Forge, yielding both rich and lean wash ore, and rock and pipe ore, of the same general character.

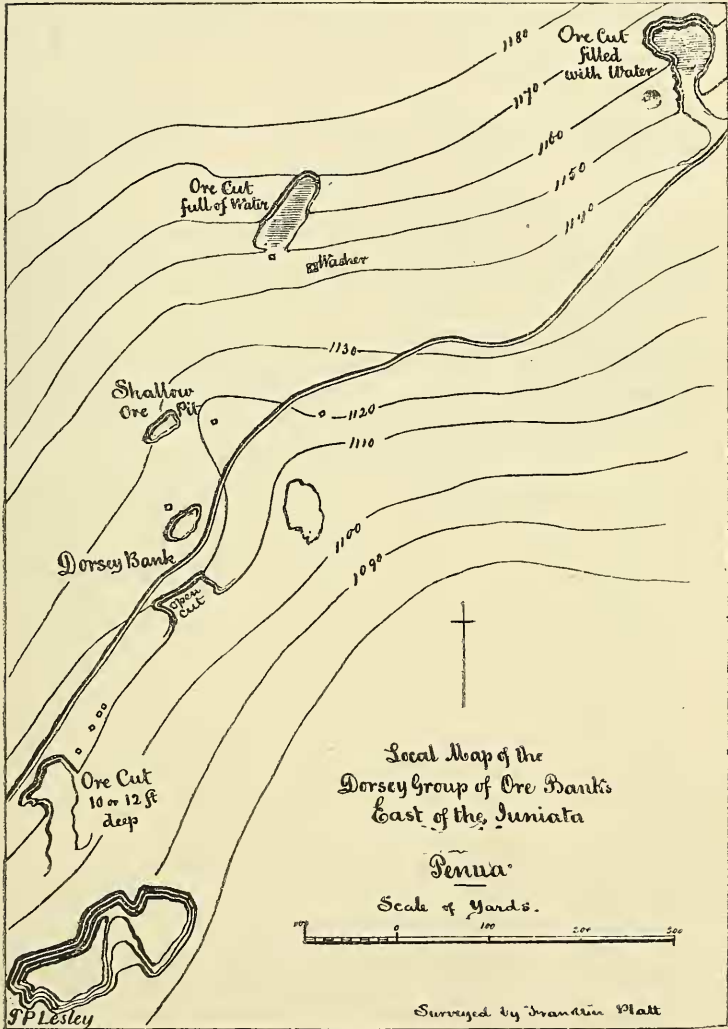
The same statement holds good as to Canoe Valley, although its narrowness does not permit its anticlinal to bring the lowest horizon of ore to the surface.

In Sinking Valley the two sides of its dying anticlinal bring the ore-outcrops together about three miles south of the river. The following are some of the ore banks: on the south side, Pine Hill Bank ($\frac{1}{2}$ mile from the river); Moore's Pipe Ore Diggings (1 mile); Galbraith's Pipe Ores ($1\frac{1}{2}$ mile); Robinson's Bank ($2\frac{1}{2}$ miles). On the northwest side are Gentzhammer's and other outcrops.

It is a serious question why mines of Brown Hematite Iron Ore have not been opened on the Juniata River above the mouth of Spruce Creek. This question seems to be answered by my section along the river, fig. 1. It is evident that the horizon of the Pennsylvania Furnace or Cale Hollow ores scarcely rises on the back on the Canoe Valley axis to the level of the valley bed, and is immediately carried down again by the syncli-

nal of Canoe mountain. It is then visible in Sinking Creek Valley, as just stated. Whether any large quantities of ore underlie the river bed

FIG. 44.



below Union Furnace and above Spruce Creek Station remains to be determined by future trial shafts along the line of the Pennsylvania Railroad.

INVESTIGATION OF IRON ORES AND LIMESTONES FROM
MESSRS. LYON, SHORB & CO'S IRON ORE BANKS ON SPRUCE
CREEK, HALF MOON RUN AND WARRIOR'S MARK RUN, IN
CENTRE, BLAIR AND HUNTINGDON COUNTIES, PA.

By F. A. GENTH.

(Read before the *American Philosophical Society*, February 6th, 1874.)

NO. 1. EAST PENNINGTON BANK.

The greater portion of thirteen specimens, received for examination, was compact, dull, of various shades of brown and had like No. 1 an admixture of dark brown pitchy ore; other portions were porous and had the cavities lined with botryoidal fibrous brown limonite, others were stalactitic. Some of the ore had lost a part of its water of hydration and had changed into turgite and even into hematite. Many of the pieces showed a considerable admixture of manganese minerals, such as wad, minute quantities of pyrolusite and perhaps psilomelane, some contained a large quantity of rounded grains of quartz.

An average of the whole showed the following composition :

Ferric oxide	=	65.88	=	44.77	Metallic Iron.
Manganic oxide	=	6.00	=	4.18	Metallic Manganese.
Cobaltic	"	0.34			
Alumina		trace			
Magnesia		0.26			
Lime		trace			
Phosphoric acid		0.22	=	0.097	Phosphorus.
Silicic acid		6.38			
Quartz		7.87			
Water		13.05			
		<hr/>			
		100.00			

100 Iron and Manganese contain 0.197 Phosphorus.

NO. 2. WEST PENNINGTON BANK.

Five specimens were submitted for examination. The ore was mostly of various shades of yellowish brown to dark hair-brown and without lustre; in some was an admixture of a dark blackish brown ore with sub-conchoidal fracture and a resinous lustre; some portions had a slight waxy lustre, others were earthy and dull. It was amorphous, but in places the cavities were lined with a coating of brown fibrous limonite. On being breathed upon, it developed a strong argillaceous odor.

An average of the five specimens contained :

Ferric oxide	=	70.93	=	49.65 Metallic Iron.
Manganic oxide	=	0.38		
Cobaltic	"	trace		
Alumina		2.81		
Magnesia		0.14		
Lime		0.08		
Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		4.38		
Quartz		7.91		
Water		13.00		
		<hr/>		
		100.00		

100 Iron contain 0.32 Phosphorus.

NO. 6. RUMBARGER BANK.

A sample of ore was taken from a pile alongside of the Bank. It is mostly amorphous and compact, also somewhat porous, and has the cavities lined with a thin coating of fibrous limonite; the cavities are also coated with red ochre and at times with yellow ochre.

The composition was found to be as follows :

Ferric oxide	=	74.16	=	51.91 Metallic Iron.
Manganic oxide		trace		
Alumina		3.06		
Magnesia		0.24		
Lime		trace		
Phosphoric acid		0.36	=	0.158 Phosphorus.
Silicic acid		6.11		
Quartz		3.94		
Water		12.13		
		<hr/>		
		100.00		

100 Iron contain 0.30 Phosphorus.

NO. 11. LYTLE BANK.

The sample received for examination consisted mainly of amorphous compact brown ore, intermixed with fine fibrous limonite. The fibres are from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch in length and form botryoidal coatings; sometimes divergent. The outside covered with yellowish ochreous ore.

The analysis gave :

Ferric oxide	=	82.00	=	57.40 Metallic Iron.
Manganic oxide	=	trace		
Alumina	=	1.94		
Magnesia		0.17		
Lime		trace		

Phosphoric acid	0.37	=	0.16 Phosphorus.
Silicic acid	2.98		
Quartz	=	0.44	
Water	=	12.10	
		<hr/>	
		100.00	

100 Iron contain 0.278 Phosphorus.

NO. 14. BULL BANK.

The samples for investigation, five in number, were taken from piles of ore taken out about thirty years ago. One consisted of a beautiful fibrous limonite of a pale hair-brown color and silky lustre, much resembling that from the Lytle Bank, but of fibres two inches in length. The others represented the amorphous ores. They are compact, of various shades of brown, without lustre; they contain more or less cavities, partly filled with ochreous ore of a yellowish or reddish color. The amorphous ores have, on being breathed upon, a strong argillaceous odor.

a. Pure Fibrous Limonite.

Ferric oxide	=	81.48	=	57.04 Metallic Iron
Manganic oxide	=	0.07		
Alumina	=	0.49		
Magnesia	}	traces.		
Lime				
Phosphoric acid		0.08	=	0.035 Phosphorus.
Silicic acid		3.98		
Water		13.90		
		<hr/>		
		100.00		

100 Iron contained 0.061 Phosphorus.

b. Average of the five Samples.

Ferric oxide	=	74.85	=	52.40 Metallic Iron.
Manganic oxide	=	0.29		
Cobaltic oxide		0.21		
Alumina		2.42		
Magnesia		0.12		
Lime		trace.		
Phosphoric acid		0.24	=	0.105 Phosphorus.
Silicic acid		4.15		
Quartz		5.92		
Water		11.80		
		<hr/>		
		100.00		

100 Iron contained 0.20 Phosphorus.

NO. 15. POND BANK NO. 1.

Two of the four specimens received were of a dark brown porous amorphous ore with very little lustre, more or less mixed with yellowish and reddish ochreous ore; the third piece was of a paler brown and contained small quantities of fibrous ore, the fourth was an ochreous ore of a pale brown and yellowish color. An average of the four samples contained:

Ferric oxide	=	78.68	=	55.08 Metallic Iron.
Manganic oxide	=	0.42		
Cobaltic	"	trace.		
Alumina		2.89		
Magnesia		0.20		
Lime		trace.		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		3.17		
Quartz		1.71		
Water		12.77		
		<hr/>		
		100.00		

100 Iron contain 0.127 Phosphorus.

NO. 16. RED BANK NO. 1.

Five samples of ore received. It is generally an amorphous compact ore, with a considerable admixture of sand. Some is more porous, and has the cavities lined with fibrous limonite, and more or less filled with clay. Emits, when breathed upon, a strong argillaceous odor. Part of the specimens had lost a portion of their water of hydration.

The analysis of an average sample gave:

Ferric oxide	=	65.44	=	45.81 Metallic Iron.
Manganic oxide	=	0.13		
Cobaltic oxide		trace		
Alumina		5.31		
Magnesia		0.16		
Lime		trace		
Phosphoric acid	=	0.21	=	0.09 Phosphorus.
Silicic acid		6.76		
Quartz		12.78		
Water		9.21		
		<hr/>		
		100.00.		

100 Iron contain 0.195 Phosphorus.

NO. 19. WHORELL BANK.

Two pieces of a fine brown porous amorphous ore of various shades, between yellowish and dark-brown; some portions showing a slight pitchy lustre; the greater part is dull. Has a strong argillaceous odor when breathed upon.

The analysis of an average sample gave :

Ferric oxide	=	69.71	=	48.80 Metallic Iron.
Manganic oxide		0.46		
Cobaltic oxide		trace		
Alumina		3.37		
Magnesia		0.08		
Lime		trace		
Phosphoric acid	=	0.97	=	0.43 Phosphorus.
Silicic acid		3.51		
Quartz		9.60		
Water		12.30		
		<hr/>		
		100.00		

100 Iron contain 0.87 Phosphorus.

NO. 21. WRYE BANK.

Five specimens received. The ore is amorphous, porous, and scoriaceous. Some of the cavities are lined with a thin coating of fibrous ore. The more compact pieces contain a large admixture of rounded quartz grains.

An analysis of an average sample gave :

Ferric oxide	=	77.00	=	53.90 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		2.15		
Magnesia		0.14		
Lime		0.15		
Phosphoric acid		0.19	=	0.08 Phosphorus.
Silicic acid		2.60		
Quartz		5.53		
Water		11.88		
		<hr/>		
		100.00		

100 Iron contain 0.15 Phosphorus.

NO. 24. DRY HOLLOW BANK.

Amongst the eight specimens received for examination was one of a beautiful variety of fibrous limonite; the fibres are of about one inch in

length, also divergent and radiating; color dark brown, lustre silky; the other ores were both compact and porous amorphous brown limonites, some with the cavities lined with fibrous ore, others having them filled with ochreous clayish ores. Some of the pieces give a strong argillaceous odor, when breathed upon.

a. Pure Fibrous Limonite.

Ferric oxide	=	83.13	=	53.19 Metallic Iron.
Manganic oxide	=	0.15		
Alumina	=	0.74		
Magnesia		0.09		
Lime		trace		
Phosphoric acid		0.50	=	0.22 Phosphorus
Silicic acid		2.47		
Water		12.92		
		<hr/>		
		100.00		

100 Iron contain 0.37 Phosphorus.

b. Average of the eight Specimens.

Ferric oxide	=	75.90	=	53.13 Metallic Iron.
Manganic oxide	=	0.16		
Cobaltic oxide	=	trace		
Alumina	=	2.44		
Magnesia		0.20		
Lime		trace.		
Phosphoric acid		0.54	=	0.24 Phosphorus.
Silicic acid		2.74		
Quartz	=	7.84		
Water		10.18		
		<hr/>		
		100.00		

100 Iron contain 0.45 Phosphorus.

No. 24. *b.* RED BANK OF DRY HOLLOW.

An examination of six specimens, showed the general character of the ore to be amorphous, of a dark brown color, and compact; some pieces have cavities lined with yellowish brown and dark brown fibrous limonite; others have rounded quartz grains disseminated through the mass. A portion of the ores has lost part of the water of hydration. The cavities and fractures are frequently coated or filled with a brownish red ochreous ore.

An average sample of the whole contained :

Ferric oxide	=	80.34	=	56.24 Metallic Iron.
Manganic oxide		0.52		

Cobaltic oxide	trace		
Alumina	1.66		
Magnesia	0.13		
Lime	trace		
Phosphoric acid	0.49	=	0.215 Phosphorus.
Silicic acid	3.18		
Quartz	2.63		
Water	11.05		

100.00

100 Iron contain 0.38 Phosphorus.

NO. 27. KERR AND BREDIN BANK.

The three specimens received show the ore to be mostly amorphous and compact, and of various shades of brown, also earthy; some parts are porous and the cavities lined with fibrous limonite, sometimes in botryoidal forms. On being breathed upon, develops a strong argillaceous odor.

The average of the samples contained :

Ferric oxide	=	70.67	=	49.47 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		3.91		
Magnesia		0.26		
Lime		trace		
Phosphoric acid	=	0.19	=	0.08 Phosphorus.
Silicic acid		5.48		
Quartz		6.80		
Water		12.33		

100.00

100 Iron contain 0.16 Phosphorus.

NO. 28. HOSTLER BANK.

One specimen of so-called "Pipe Ore." Amorphous, compact and earthy, brown to yellowish brown. Porous. Stalactitic. Coated with yellowish and reddish ochreous ore.

The analysis gave :

Ferric oxide	=	78.58	=	55.01 Metallic Iron.
Manganic oxide		0.08		
Alumina		0.88		
Magnesia		0.54		
Lime		0.30		
Phosphoric acid	=	0.36	=	0.158 Phosphorus.

Silicic acid		4.25	
Quartz	=	2.60	
Water	=	12.41	
		<hr/>	
		100.00	

100 Iron contain 0.28 Phosphorus.

No. 29. PENNSYLVANIA BANK.

a. Two samples received for examination.

Amorphous brown compact ore mixed with ochreous yellowish or reddish ore; Porous, some of the cavities lined with a very fine coating of fibrous ore.

b. So-called Pipe ore.

Amorphous porous ore, in columnar masses, the cavities filled with ferruginous clay.

c. Quartz grains, cemented by brown amorphous limonite, and disseminated through it, patches of hydrous manganic oxide and perhaps of psilomelane.

a. Average of two Samples.

Ferric oxide	=	81.55	=	57.10 Metallic Iron.
Manganic oxide		0.10		
Cobaltic oxide		trace		
Alumina		1.49		
Magnesia		0.47		
Lime		trace		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		2.98		
Quartz		1.55		
Water		11.70		
		<hr/>		
		100.00		

100 Iron contain 0.13 Phosphorus.

b. Pipe Ore.

Ferric oxide	=	83.74	=	58.62 Metallic Iron.
Manganic oxide	=	0.31		
Cobaltic oxide		trace		
Alumina		0.33		
Magnesia		0.34		
Lime		trace		
Phosphoric acid		0.14	=	0.06 Phosphorus.
Silicic acid		2.57		
Quartz		0.44		
Water		12.13		
		<hr/>		
		100.00		

100 Iron contain 0.10 Phosphorus.

c. Sandrock.

Ferric oxide	=	43.65	=	30.56 Metallic Iron.
Manganic oxide	}	1.55		
Cobaltic oxide				
Alumina		2.43		
Magnesia		1.64		
Lime		0.12		
Phosphoric acid		0.27	=	0.12 Phosphorus.
Silicic acid		5.19		
Quartz		36.52		
Water		8.63		
		<hr/>		
		100.00		

100 Iron contain 0.39 Phosphorus.

OLD CUT NORTH OF GATESBURG. *

A peculiar looking amorphous ore, of a brown and yellowish-brown color, uneven to subconchoidal fracture, dull or of slight waxy lustre, inclining to resinous. It has a strong argillaceous odor when breathed upon.

The composition of the one specimen, which I received for examination, was found to be :

Ferric oxide	=	71.63	=	50.14 Metallic Iron.
Manganic oxide	}	0.53		
Cobaltic oxide				
Alumina		4.63		
Magnesia		0.37		
Lime		trace		
Phosphoric acid	=	1.67	=	0.73 Phosphorus.
Silicic acid		3.69		
Quartz		4.64		
Water		12.84		
		<hr/>		
		100.00		

100 Iron contain 1.43 Phosphorus.

The amount of metallic iron in the calcined ores is as follows :

No. 1.	East Pennington Bank.....	51.49	per cent.
“ 2.	West Pennington Bank.....	57.07	“
“ 6.	Rumbarger Bank.....	59.08	“
“ 11.	Lytle Bank.....	65.30	“
“ 14.	Bull Bank— <i>a</i> , fibrous ore.....	66.25	“
“ “	“ “ — <i>b</i> , average.....	59.41	“

*Mr. Platt's Station 568.

No. 15.	Pond Bank, No. 1.....	63.14	per cent.
“ 16.	Red Bank, No. 1.....	50.46	“
“ 19.	Whorell Bank.....	55.64	“
“ 21.	Rye Bank.....	61.17	“
“ 24.	Dry Hollow Bank— <i>a</i> , fibrous ore..	66.82	“
“ “	“ “ “ — <i>b</i> , average.	59.15	“
“ 24 <i>b</i> .	Red Bank of Dry Hollow.....	63.23	“
“ 27.	Kerr and Bredin Bank.....	56.43	“
“ 28.	Hostler Bank.....	62.80	“
“ 29.	Pennsylvania Bank— <i>a</i> , average....	64.67	“
“ “	“ “ — <i>b</i> , pipe ore....	66.71	“
“ “	“ “ — <i>c</i> , sandrock... ..	33.44	“
	Ore from Old Cut N. of Gatesburg.....	57.52	“

All these ores were examined for Sulphur and Sulphuric acid, but not a single one gave a decided reaction for either. They were also examined for Titanium, Chromium, Vanadium, and other metals, but with negative results.

Their only constituent, which has an injurious effect upon the quality of the iron, produced from the same, is phosphoric acid; most of them, however, contain it in too small a quantity to be of much harm. Only two of the samples contain it in a larger proportion.

For better comparison, I will arrange the amounts of Phosphorus which would be contained in 100 parts of iron, provided no loss of either would be sustained :

Fibrous ore of Bull Bank.....	0.06	Phosphorus.
Pipe ore of Pennsylvania Bank.....	0.10	“
Average ore of “ “	0.12	“
Pond Bank, No. 1.....	0.127	“
Wrye Bank.....	0.15	“
Kerr and Bredin Bank.....	0.16	“
Red Bank No. 1.....	0.195	“
N. E. or Upper Pennington Bank.....	0.197	“
Average of Bull Bank.....	0.20	“
Lytle Bank.....	0.278	“
Hostler Bank.....	0.28	“
Rumbarger Bank.....	0.30	“
S. W. or Lower Pennington Bank.....	0.32	“
Fibrous ore of Dry Hollow Bank.....	0.37	“
Red Bank of Dry Hollow.....	0.38	“
Sandrock of Pennsylvania Bank.....	0.39	“
Dry Hollow Bank.....	0.45	“
Whorell Bank.....	0.87	“
Old cut N. of Gatesburg.....	1.43	“

Of all the ores submitted for examination only two appeared to be in a

sufficient state of purity to throw light upon their constitution, as they were crystalline, and free from visible impurities. For this reason they were examined separately.

Taking into consideration only their principal constituents, viz : Ferric oxide, Silicic acid and water, the question arises, in which form the silicic acid is present, as it is undoubtedly in chemical combination with the ferric oxide and *not* in the form of a mechanical admixture of sand. If pieces of these fibrous limonites are placed into strong chlorhydric acid, all the ferric oxide will be extracted, and the silicic acid will remain in the shape of the original pieces, of a snow-white color and fibrous structure. The only hydrous ferric silicates, which are known, are Anthosiderite and Degeroeite. The former is a crystalized mineral, which has a composition, represented by the formula $2\text{Fe}_2\text{O}_3, 9\text{SiO}_2+2\text{H}_2\text{O}$. It is very probable that, although observed in its pure state only at one locality, it occurs frequently as an admixture with other iron ores.—If we calculate for the 3.98 per cent. of silicic acid in the fibrous mineral from Bull Mine, the requisite quantities of ferric oxide and water, we find 2.36 per cent. of ferric oxide and 0.26 per cent. of water, making an admixture of 6.60 per cent. of anthosiderite. The atomic ratio between the remaining 79.12 per cent. of ferric oxide and 13.64 per cent. of water is 1 : 1.53 or very near 2 : 3, showing the hydrous ferric oxide to be limonite = $2 \text{Fe}_2 \text{O}_3, 3 \text{H}_2 \text{O}$.

If in the same manner we examine into the composition of the fibrous mineral from the Dry Hollow, the 2.47 silicic acid require 1.46 per cent. ferric oxide and 0.17 water, giving an admixture of 4.10 per cent. of anthosiderite.—The atomic ratio between the remaining 81.67 per cent of ferric oxide and 12.75 per cent. of water is 1: 1.4, which also shows the ferric hydrate to be limonite, which, however, has already lost a small part of its water.

The above analyses show besides the mechanically admixed rounded grains of sand, which I distinguish as “quartz,” a considerable quantity of silicic acid, which is in chemical combination, probably as a hydrous ferric oxide. But as it is impossible to say what the true character of this mineral may be, whether anthosiderite, or degeroeite a silicate of the composition $\text{Fe}_2 \text{O}_3, 2\text{SiO}_2+3\text{H}_2\text{O}$ or a species not yet known in its pure state, suffice it to say that all these ores are mechanical mixtures of limonite with hydrous ferric silicate and minute quantities of hydrous ferric phosphate, perhaps dufrenite or cacoxenite; some of the ores contain besides these, small quantities of manganese ores, mostly the so-called “bog-manganese” or wad, but also pyrolusite and psilomelane.

It is a very remarkable fact that, although these iron ores are to a great extent at least, the result of the decomposition of limestones and by them precipitated, that almost the entire amount of lime has been washed out of them and only traces are remaining; of the second constituent of the limestones, the magnesia, a somewhat larger quantity is left behind, owing undoubtedly to the lesser solubility of its carbonate in carbonic acid water.

Of the limestones only a few typical varieties have been more fully investigated, especially those from the Hostler and Pennsylvania Banks.

LIMESTONE AT HEAD OF HOSTLER BANK.

It has a fine crystalline granular structure and is mottled, whitish and grey; the surface is coated with ochreous argillaceous iron ore.

A pure specimen from which the iron had been carefully removed, contained:

Carbonate of Iron	=	0.80	=	0.39	Metallic iron.
“ “ Manganese	=	0.19	=		
“ “ Magnesia	=	35.19	=	16.76	Magnesia.
“ “ Lime	=	59.44	=	33.28	Lime.
Quartz and Silicic Acid		3.84			
Alumina		0.54			
		<hr/>			
		100.00			

The atomic ratio between Magnesia and Lime is 1:1.4, which is the composition of some of the “pearlspar” varieties of dolomite.

LIMESTONE IN HOSTLER BANK.

It lies four feet thick over 33 feet of pipeore. It has an ash-grey color and a very fine grain, which is hardly perceptible to the naked eye; very friable. Its composition was found to be:

Carbonate of Iron	=	0.50	=	0.24	Metallic Iron.
“ “ Manganese	=	0.24	=		
“ “ Magnesia	=	42.52	=	20.25	Magnesia.
“ “ Lime	=	51.82	=	29.02	Lime.
Quartz and Silicic Acid		4.33			
Alumina		0.42			
Water		0.17			
		<hr/>			
		100.00			

The atomic ratio between Magnesia and Lime is 1:1, which shows it to be a true dolomite.

UPPER LIMESTONE FROM PENNSYLVANIA BANK.

Dark grey compact, slightly crystalline.

The analysis gave the following results:

Carbonate of Iron	=	1.31	=	0.63	Metallic Iron.
“ “ Manganese	=	0.18	=		
“ “ Magnesia	=	3.98	=	1.90	Magnesia.
“ “ Lime	=	72.67	=	40.69	Lime.
Quartz and Silicic Acid		18.05			
Alumina		3.81			
		<hr/>			
		100.00			

The atomic ratio between magnesia and lime is 1:15.

LIMESTONE IN THE PENNSYLVANIA BANK.

Pale ash grey, very finely crystalline, rough to the touch like rotten stone, very friable and easily falling to powder.

Its composition was found to be :

Carbonate of Iron	=	0.45	=	0.22	Metallic Iron.
“ “ Manganese	=	0.06			
“ “ Magnesia	42.39	=	20.19	Magnesia.	
“ “ Lime	51.25	=	28.70	Lime.	
Quartz and Silicic Acid	5.03				
Alumina	0.82				
					100.00

The atomic ratio between Magnesia and Lime=1 : 1, shows it to be a true dolomite.

ANOTHER VARIETY OF LIMESTONE IN THE PENNSYLVANIA BANK.

Yellowish grey, soft, rotten, feels rough to the touch, sandy ; crystalline ; has a laminated structure. Its analysis gave :

Carbonate of Iron	=	1.18	=	0.57	Metallic Iron.
“ “ Manganese	trace				
“ “ Magnesia	35.51	=	16.91		
“ “ Lime	45.73	=	25.61		
Quartz and Silicic Acid	15.83				
Alumina	1.75				
					100.00

The atomic ratio between Magnesia and Lime=1 : 1.08 proves it also to be a true dolomite.

It is remarkable that the limestones and dolomites, of which I give the analyses, contain almost the entire amount of silicic acid as quartz, only a small quantity is present as soluble silicic acid and in combination with alumina. If the limestones and dolomites are dissolved in acid, the quartz remains often as a scoriaceous mass or in irregular sandy but not rounded or water-worn grains ; sometimes it forms large coherent slaty masses in the limestone, frequently filled with minute cavities, previously occupied by rhombohedral crystals of dolomite. Similar pieces found in the Pennsylvania Bank are white, like porcelain and show the same cavities of rhombohedral crystals. Other varieties of limestone in the Pennsylvania Bank have a still greater admixture of quartz and are a real calciferous sand rock.*

UNIVERSITY OF PENNSYLVANIA, January 23d, 1874.

* These analyses summed up about 100, most of them a little above, one or two a little below, but all within the limits of unavoidable error ; for better comparison I thought it advisable to calculate them for 100.00, from the actual result obtained. (F. A. Genth.)

ANALYSES* OF PENNSYLVANIA PIPE, AND PENNINGTON ORE.

3, DEVONSHIRE TERRACE, KENSINGTON, LONDON, W.,

January 5th, 1871.

DEAR SIR:—Herewith I beg to forward you the results of my analysis of the two samples of ore, marked, respectively, "Pipe Ore" and "Pennington Bank."

The whole of the samples were intimately pulverized together in each case; they contain

	PIPE ORE.	PENNINGTON BANK.
Silica	10.84	5.42
Peroxide of Iron.....	73.18	79.05
Protoxide of Iron.....	.75	
Alumina.....	2.51	1.29
Oxide of Manganese.....	traces.	.11
Carbonate of Lime.....	.20	
Carbonate of Magnesia.....	1.20	Magnesia. .11
Phosphoric Acid.....	.17	.04
Combined Water.....	9.09	10.57
Moisture.....	1.81	3.55
Sulphur05	
	<hr/>	<hr/>
	99.80	100.14
Metallic Iron.....	51.81	55.34
“ “ exclusive of Water.....	58.25	64.35

Both these samples are rich iron ores, sample "Pennington Bank" being nearly pure brown hematite. The pipe ore is a harder ore than "Pennington Bank" ore.

I consider both samples of ore adapted for the manufacture of Bessemer Pig.

Believe me to remain, yours, very faithfully,

EDWARD RILEY, F. C. S.,

Metallurgist, Analytical and Consulting Chemist.

ANALYSIS OF "PIPE ORE," "KERR & BREDIN" AND PENNINGTON BANK ORES, BY CH. ALDENDORF, SUB-DIRECTOR OF THE GEORGE-MARIEN HUTTE HIGH FURNACES, MARCH 9, 1872.

	PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Water	11.190	10.540	12.340
Insoluble Residue, $\left. \begin{array}{l} \text{Si O}^2 \\ \text{Al}^2\text{O}^3 \end{array} \right\} \dots$	5.120	13.400	5.450
Oxide of Iron, $\text{F}^2\text{O}^3 \dots \dots$	82.050	73.560	79.450

* These analyses by an English chemist of well known reputation, especially entrusted by Mr. Bessemer with his numerous and important analyses, are here added for comparison.

		PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Alumina,	Al_2O_3	1.650	2.840	3.096
Oxide Manganese,	Mn_2O_3	0.270	0.190	0.440
Chalk,	CaO	0.370	0.460	0.440
Magnesia,	MgO	trace.	trace.	trace.
Phos. Acid,	P_2O_5	0.080	0.280	0.064
Sulphuric Acid,	S_2O_3	trace.	trace.	trace.
		100.730	101.270	101.280
Per cent. Metallic Iron.....		57.435	51.492	55.61
Phosphorus in 100 Iron.....		0.061	0.238	0.053
Per ct. Iron, excluding Water,		64.150	56.075	62.540

“The Pipe and Pennington Ores if melted together would make a very superior Bessemer Iron. The Kerr & Bredin *alone* an inferior Bessemer Iron. A separate analysis, however, of Kerr & Bredin shows that its Phosphorus is concentrated in the Clay thereto attached, and it may be that this Ore may be made available for Bessemer Pig, by proper treatment before smelting.”

ANALYSIS OF PENNSYLVANIA FURNACE LIMESTONE BY OTTO WUTH,
CHEMIST, PITTSBURGH, Pa.

From Quarry near the Furnace—a grey crystalline Stone :

Silicic Acid.....	5.08
Alumina.....	1.34
Carbonate of Iron.....	.69
“ “ Lime.....	91.53
“ “ Magnesia.....	1.31
Sulphate of Lime.....	trace.
Organic Matter.....	.05

From Ore Bank Rail Road Cut — a partly crystalline drab-colored stone :

Silicic Acid.....	4.93
Alumina.....	.24
Carbonate of Iron.....	.87
“ “ Lime.....	84.66
“ “ Magnesia.....	8.98
Sulphate of Lime.....	.11
Organic Matter.....	.21

Gray Crystalline Stone, south side of road from Half Moon Run to Hostler Bank, near the Half Moon Run.

Silicic Acid.....	2.71
Alumina.....	.11
Carbonate of Iron.....	1.80
" " Lime.....	83.91
" " Magnesia.....	11.14
Sulphate of Lime.....	.12
Organic Matter.....	.21

Smooth Grey Stone from north side of road near the foregoing :

Silicic Acid.....	6.87
Alumina.....	1.35
Carbonate of Iron.....	.75
" " Lime.....	86.42
" " Magnesia.....	4.24
Sulphate of Lime.....	.21
Organic Matter.....	.16

MINING METHODS.

It will be seen from the above descriptions, that mining operations have been mostly carried on in this region in an irregular and primitive style. I requested Mr. John W. Harden to give me the benefit of his large and varied experience as a mining engineer and superintendent, both in the English and in the American collieries and iron mines, in stating what ought to be the most economical mode of entering on and exhausting the Nittany Valley limestone deposits. His recent success in increasing the export of limonite from Pinegrove Furnace banks south of Carlisle, by a judicious application of a system of regular approaches, justifies me in placing a high value on any practical suggestions he has to offer respecting similar deposits.

He therefore visited the Pennington, Dry Hollow, Kerr & Bredin, Pennsylvania Furnace, and other Banks above described; and the following extracts from his report will show that there is but one conclusion to arrive at, and that a very simple one; viz., that the system to be almost universally adopted is that by open-cuts, approached from the direction of the railway, at the lowest possible levels, and worked to the right and left, in advancing slopes, one above the other; that the deep rich-ores should be worked at the same time with the upper wash-ores, or not greatly in arrear of them, so that the wash-ore thus won may pay the expenses of uncovering the richer lower ores; and that where surface water is scarce, bore-holes should be sunk to serve the double purpose of exploration and water supply.

Whether additional and larger furnaces be erected in the Valley, or whether the ores be sent by rail to the Iron Works in Eastern and

Western Pennsylvania, in both contingencies an exploitation of ore must be provided for, amounting annually to many hundred thousand tons per annum.

The largest mining operation in the Valley being that of the Pennsylvania Furnace, Mr. Harden takes the account book of the works at that point for a practical basis of calculation of the cost of exploitation. It is evident that mining conditions through the Valley are very similar. No system of between-rock mining will be required for many years. But exploring drifts and shafts will be necessary, and under-cutting where the clays are destitute of ore and too thick to remove. Most of the work however must be done in open cuts of great extent, with simple machinery for obtaining water and washing the entire mass of ore-ground to the very bottom, or to the deep rock-ores, which can be quarried and used without washing. In many cases the rock-ore, and in some cases the clay-ore, can be followed downward between solid masses of limestone rock ; but this must be done in connection with the open-cuts.

At the Pennington Banks there appear to be from 50 to 80 feet of wash-ore and clays overlying from 8 to 16 feet of rock-ore.

At the Dry Hollow Banks there is a stripping at the surface from 5 to 15 feet deep containing but little ore ; then wash-ore with sands and sandy clays to a depth of 20 or 30 feet before reaching rock-ore.

At the Hostler Banks a top stripping of 5 feet or more, covers 50 to 60 feet of wash-ore in clay, under which lie the pipe-ores, which are reported as having been in one place over 40 feet deep ; limestone layers covering and dividing the mass. The miner who sunk the last shaft informed Mr. Harden that it went down 60 feet through wash-ore, 5 feet through solid limestone, and 7 feet in pipe-ore on one side of it, and wash-ore on the other side ; water stopping further sinking.

At the Pennsylvania Furnace Banks, the entire mass from the surface to the floor of the quarry is wash-ore mixed with clay and sand. The whole of this mass has been washed. "In one place a 13 feet face of excavation gave 3 to 4 feet of surface soil and sienna-colored sandy-wash, the remainder below it being a sandy, whitish ochre, and sienna colored clay, streaked and marbled with red and brown, and some, not large lumps of ore. Scattered through the whole, in considerable quantity in some places, are small pieces of quartz which are picked out after the ore has passed over the trays. In another part of the diggings this quartz, from the size of shot to lumps 3 or 4 inches thick, is scattered through the mass.* Some masses of this quartz, of one or two cubic feet in size, lie about the quarry.

"In a deeper part of the diggings where the face of iron and work measures 45 or 50 feet, in two heights of 15 and 30 to 35 feet, now being moved to the inclined plane for washing, the face is made up of sand and various colored clays holding ore, all of which is washed. Limestone appears at the bottom and pipe-ore has been found underneath it."

* Mr. Harden gives an analysis of this quartz : Water, 0.50, Silica, 96.00, Iron and alumina, 1.76, undetermined, 1.68.

Mr. Harden advises that the stripping of wash-ore be not carried on far in advance of the lifting of the rock and pipe-ore at the bottom; because, even where the farming interest does not interfere, such a plan "disturbs the equal distribution of dead work" and prevents the rejection of those parts of the stripping which do not pay well for washing. Ample room ought to be got early for lifting the entire mass of rich bottom ores.

"With a good roomy open cutting the mass of wash ore should cost no more to move than so much ordinary excavation." "The ore-earth is loaded into cars carrying $29\frac{1}{2}$ cubic feet, led by horses to the foot of the incline, 300 to 500 feet, whence it is lifted 37 feet on a grade of 14° , to a level with the washers, by a 12 inch cylinder steam engine, 2 foot stroke, and pair of 8 foot drums. The car load is again dragged 150 feet and dumped into the washing troughs, in which revolve three Archimedian screw-propeller shafts 20, 26, and 26 feet long respectively. The shafts are of decagonal timber, 15 inches in diameter on the facets of which are screwed cast iron blades. The ore travels 72 feet, and is dropped into two classifying screens, the sand and mud being floated off to the settling dam. The screens have $\frac{1}{4}$ inch and $\frac{1}{12}$ inch meshes. The ore falls on sheet iron trays where the quartz is picked out. The washers are driven by a 16 inch cylinder engine, 54 inch stroke; the steam being generated in two double flue boilers 30 feet long and 40 inches in diameter. The water arrives by an aqueduct 2000 feet long mounted on tressels arranged along the top of the hill. It is fed by a pipe of 12 inch diameter laid up the hill side to a vertical height of 110 feet above a double Worthington pump with 20 inch steam and 15 inch water cylinders; the fall of reservoir is 1 foot in 250. The steam boilers for the pump are also 30 feet long by 40 inches diameter, driving also a Blake stone-crusher, used for the flux.

The digging of the ore is said to be done by contract at half the price of ordinary earth.

Six cubic yards of earth has been found to produce an average of one ton of washed ore, the diggers being paid 16 cents per car-load of 29.58 cubic feet = 23.67 of solid earth. A cubic yard will therefore cost $18\frac{1}{4}$ cents and a ton of ore \$1.09. The ore delivered at the furnace costing \$2, there remains 91 cents for leading, raising, washing, picking and delivery.

But the great economy of this operation can be duly realized only by remembering that the earth washed and ore utilized is that which under any other circumstances would be dumped on one side as "spoil," and as such chargeable against the lower and better ore. "Seeing also that in so utilizing this (otherwise) refuse just so much dead charge is removed, we are led to anticipate a less costly production of the ore which follows it; and we have ground for contemplating equally favorable results at other banks, the same course being pursued."

The Furnace stands under the high bank of Spruce Creek, with its

village occupying the upper slopes on both sides of the Creek, and the farms stretching south and east to the foot of the mountain. It is a stack 43 feet high, $9\frac{1}{2}$ feet across the boshes, 48 inch tunnel, slope of boshes 68° , hearth $5\frac{1}{2}$ feet high, 48 inches wide at top and 30 inches at the bottom, with two cold air tuyeres, fed from blowing-tubs 6.4 long, driven by a 16 inch cylinder engine, $4\frac{1}{2}$ feet stroke. A Cameron blast 22 inch steam cylinder and 6×5 feet blowing-tub is held in reserve. Steam is generated in three 30 feet cylinders, 42 inches in diameter, fed with Creek water by a No. 4 Cameron steam pump, with a No. 8 Earl steam pump in reserve. Another steam-engine drives three lathes.

The uniform yield of the furnace has been 100 tons per week. It is now changed to hotblast, by the recent erection of a Pleyer oven $17 \times 5 \times 2\frac{1}{2}$ feet, with six tiers of pipes, in a building 17×12 .

THE FOSSIL ORE BELT.

On the north-west flank of the Bald Eagle Mountain the Medina Red Sand-stone and the Clinton Red Shales and Marls, all standing vertical at the out-crop, (see figs. 1, 2, 3, 4,) bring up to the surface the Upper Soft and Lower Hard Fossil Ore Beds, long and extensively worked at Frankstown in Blair County, 15 miles south of Tyrone City.

One or other of these out-crops may be noticed at three points marked on the west flank of the Bald Eagle Mountain in the Large Topographical Map accompanying this report.

On a separate and smaller Map of the same Mountain, continued to the south of Tyrone under the local name of Brush Mountain, both out-crops may be seen in the same relative positions.

On the sheet containing this smaller Map are three geological cross sections, two of which show the vertical attitude of the fossil ore-beds at Tyrone City Gap, and the third their more inclined attitude at Dysarts Mine, at the south limit of Lyon, Shorb & Co.'s lands, four miles south of Tyrone City Gap. By the time the beds reach Frankstown they get to be nearly horizontal. Beyond Hollidaysburg they become vertical again, owing to the Morrison's Cove fault (which exactly simulates the Bellefonte fault), and again they die away to the horizontal on Dunnings Creek. At Bedford they are again vertical; and so they alternately stand and fall through Virginia and Tennessee.

In the other direction from Tyrone City, north-eastward, the vertical attitude of the fossil ore-beds is pretty well maintained for forty miles; past Bellefonte, Lock Haven and Wilkesbarre, to Muncy, where they fold almost horizontally around the east end of the Bald Eagle (Muncy) Mountain.

Wherever the out-crops of the fossil ore-beds of No. V. have been examined, along their out-crops to the north-east of the Tyrone neighborhood, they have been found too thin to work; at least, for cold blast

charcoal furnace use, in the presence of the magnificent deposits of brown hematite in the Lower Silurian Limestones (No. II).

But from the neighborhood of Tyrone City Gap southward, past Frankstown, Holidaysburg and Bedford, they have paid well for mining, and continue to furnish an apparently inexhaustible fund of 30 per cent. to 40 per cent. ore to the large coke-furnaces of Blair and Cambria Counties.

By comparing my larger topographical Map with Mr. Lowrie's Land Map it will be seen that the out-crops of Fossil Ore on Lyon, Shorb & Co.'s lands range in an unbroken line from the Abner Webb tract to the Shippen tract, a distance of ten and a half ($10\frac{1}{2}$) miles, and always in an attitude nearly or quite vertical; falling off at the south end to 60° W. N.W.

The geological order of the beds at Frankstown, where they are extensively mined, is by careful measurement as follows :

Red Shale of No. V. (Clinton Group.)

e. Soft fossil ore, small single bed, 3 to 8 inches.

Red Shale, 100 feet.

d. Soft fossil ore-bed.

Yellow ochre, 10 feet.

c. Soft fossil double ore-bed.

} In all 25 to 40 inches.

Red shales and some thin sand stones, 400 feet.

Chocolate slates, 20 feet.

b. Frankstown main soft ore-bed, 14 to 16 inches.

Grey and dove colored slates, 17 feet.

Red sand stones and shales, 155 feet.

a. Hard fossil ore-bed, about 10 feet.

Red and grey sand stones of IV, to the crest of the Mountain, say 700 feet.

a. HARD FOSSIL ORE BED.

This is a layer of sand charged with peroxide of iron and full of minute fossil shells and encrinal discs the calcareous parts of which are dissolved away. It forms a bed of ore yielding by analysis about 30 per cent. of iron; and in the furnace $3\frac{1}{4}$ to $3\frac{1}{2}$ tons of it make a ton of metal, always cold-short, and therefore chiefly valuable when mixed in proper proportions with other ores.

Prof. Persifer Frazer's analysis of specimens taken from the middle bench in Dysart's Mine recently opened (see smaller Map), made for me in his laboratory in the University of Pennsylvania, is as follows :

Specific gravity : 3.26.

Sesquioxide of iron.....	38.48	} Metallic iron
Protoxide of iron.....	4.37	
Silica.....	37.99	
Alumina.....	9.56	
Lime.....	1.08	

Magnesia.....	a trace.
Alkalies.....	2.54
Phosphoric Acid.....	1.48
Sulphur.....	0.05 (trace.)
Loss by ignition.....	4.50
	Total.....
	100.00

At Howard Furnace the ore was analysed, &c., some years ago and found to contain 28 per cent. of iron.

The bed was here found standing at 80° towards the N. N. W. and only 22 inches thick.

In the end of the Mountain south of Tyrone City this bed has been recently opened at a height of 260 feet (by barometer) above the Juniata River, the slope of the surface being 40°, and the pitch of the bed at the out-crop 60° into the mountain (S. E). But this is due to the creep of the out-crop down hill. The body of the bed stands vertical.

There is 6½ feet of rock-ore between overlying sandy shales and underlying foot shales; only the upper 22 inches of the bed in six plies is here workable.

At Dysart's, 4 miles south of Tyrone city, a tunnel 20 feet long, 575 feet (bar.) above the level of the Juniata, strikes the bed pitching 50° to 60° (at the two headings, right and left)* towards the N. 50° W. About six feet of ore is here mined and sent to Pittsburgh, *via*. Tipton Station on the Pennsylvania Railroad at the foot of the mountain opposite the mine.

At the heading in Oct. 1873 was seen the following order of layers :

Fossil ore, at mouth of tunnel in soft rotten shale.....	6 inches.
Rock in tunnel.....	16 feet.
Hard lean fossil ore.....	1 " 5 inches.
Hard fossil ore.....	2 " 10 "
Clay parting.....	2 "
Hard fossil ore.....	2 " 0 "
Soft shale floor rotted into compact mud, the water bearing stratum.	

In October 1873 a Pittsburgh furnace was doing good work mixing ¼ of this Tipton (Dysart) ore with ¾ of a very pure ore, deficient in silica and alumina, which deficiency the hard fossil ore supplied; and that, without any marked prejudice to the run of the furnace as to quantity, although two-thirds of the Tipton ore went below 40 per cent. and one-third below 20 per cent. of iron; the Tipton ore making good cinder, and thus relieving a part of the pure ore from that duty. The quality of the pig-metal produced after the mixture was adopted remained unchanged.

This aspect of the future utility of this lowest deposit *a* of the fossil ore series of N. V. is important.

At Frankstown the bed sometimes reaches a thickness of ten feet.

* Higher up, red sandstone at the surface dips 78°.

On the southeast flank of Tussey Mountain at R. H. Powell's mines, ten miles southeast of Frankstown, the same bed varies from 15 to 25 feet in thickness, and shows three well-marked benches, an upper and a lower of sandy rock ore, and a middle bench, 5 or 6 feet thick, of soft rich fossil ore, which is mined by the Cambria Iron Co. and transported in large quantities ninety (90) miles by railroad *via* Huntingdon and Tyrone city across the Alleghany Mountain to the Company's furnaces at Johnstown in Cambria County, for mixing with coal-measure ores (mined back of the furnaces) and high grade ores from Lake Superior and Missouri.

This is another practical evidence of the importance of this deposit to the pig-metal make in America.

The bed is absolutely continuous and uninterrupted. Its outcrop can always be found at a well-defined elevation on the flank of the Upper Silurian Mountain, and about two-thirds of the distance from the base towards the summit. But the bed is very variable in thickness even in distances of a few hundred yards, and ought to be opened in many places along its run of nearly eleven miles through Lyon, Shorb & Company's lands, before any extensive mining plant is made.

Its solid contents *above water level* is very large. Southwest of the Tyrone gap it contains above water level from one to three million cubic yards of ore, according as its thickness varies from three to nine feet. Northeast of the gap, it contains one to two millions more, allowing for the probable general thinning of the bed in that direction; but as experience has taught us that sections of its outcrop are very likely to show an exceptionally great thickness, the estimate may be indefinitely increased.

Along the whole $10\frac{1}{2}$ miles of outcrop it runs parallel to and within less than a mile of first-class railways, (the Pennsylvania Railway, and the Bald Eagle Valley Railway,) which offer facilities for distributing it to furnaces in northern, eastern, and western Pennsylvania. It is also exposed on both sides of the Tyrone Gap, on the line of the Pennsylvania Railroad, so that a main gangway a mile long can be driven in just high enough above grade to allow of shutes on a siding.

This bed in its descent beneath the surface and water level probably suffers no such change as that which the soft fossil ores (to be next described) suffer, and it can therefore be mined hereafter to an indefinite distance downwards by shafts and slopes. This fact adds many millions of tons of available ore to the estimate given above.

SOFT FOSSIL ORE BEDS.

About 40 inches of this ore may be looked for along its outcrop wherever the deposit *c, d*, is in good order. Sometimes its three beds are near enough to mine in one gallery. Oftentimes one or another of them is wanting. Often they lie ten, twelve or more feet asunder. The variations are frequent and rapid. Several hundred feet beneath the triple bed *c, d*,

occurs at Frankstown bed *b*, so thick as to be called *there* the main bed. A hundred feet above the triple bed *c, d*, at Frankstown is still another layer a few inches thick.

It is important to note the order in which these deposits occur to the explorer descending the mountain side from the outcrop of the hard fossil ore, because it is very evident, that the occasional openings made along the range on one or other of the three principal soft fossil ore outcrops, viz. *b*;—*c, d*;—*e*;—are very misleading. The Bald Eagle Mountain was for many years condemned by geologists as destitute of *workable* fossil ore, because the number of beds was not known; no comparison of localities was made; no complete section down the mountain slope, at any one place. Since the different beds vary in thickness constantly and rapidly, and apparently under a law which may be rudely stated thus: *when one bed thickens it is at the expense of the others*, as if there was but a certain quantity of iron at command and sometimes one bed would get more than its share, and sometimes another,—it follows that the value of any tract on the mountain side can be determined only after a thorough trial of all three (five) outcrops of soft fossil ore has been made; and in no instance has this been done, in the range of $10\frac{1}{2}$ miles upon the Lyon, Shorb & Co.'s lands, nor between them and Frankstown, nor east of them.

Every road descending the west face of the mountain exposes one or more of these outcrops; the highest (lowest geologically) being always 50 or 60 yards below the hard fossil outcrop, where the sandstones of the crest commence.

The red sandstones of the crest and first steep pitch of mountain side between the crest and the hard fossil outcrop, send a multitude of fragments down over the soft yellow and red shales forming the middle slope of the mountain, and under these the soft fossil outcrops lie concealed. The gentle foot-slopes of the mountain are occupied by limestones, marls and red shales.

One of the soft fossil beds has been opened 1,300 yards northeast of Tyrone city, as shown on the Brush Mountain map accompanying this report, at an elevation of 370 feet above Railroad grade. A limestone bed crops out 70 yards down the slope (above it geographically) at 320 feet above railroad grade. The ore-bed is opened by a tunnel and "is 18 inches thick," including some thin layers of ferriferous fossil limestone. It stands "vertical," or overturned slightly so as to dip into the mountain in a direction S. 48° E.

Nothing is known of the other beds.

Experience at Danville and Bloomsburg in Eastern Pennsylvania has proved that the soft fossil ore can be extensively mined when only 16 or 18 inches thick (on a general average of the workings) as may be seen by reference to the very important chapter written on this subject by Prof. H. D. Rogers at page 440 and onward in the first volume of the Final Report of the Geology of Pennsylvania. Experience at Franks-

town has been similar. But at these localities the gentle dip has its bearing upon the economy of mining, and perhaps upon the question of depth to which the *softening of the fossil limestone into soft fossil ore* has gone. I say perhaps, because it was Mr. Rogers' fixed opinion that the fossil ore would not be found fit for mining operations along those runs of outcrop where the beds stood at a steep angle, or vertical. This opinion must be set aside, since the long horisontal gangways, at water level, at Bedford, have yielded the soft ore in a perfect condition at a depth of several hundred feet vertically beneath the outcrop.

It is safe therefore to expect, in the ten or eleven miles of ore-range to find one or more of the beds at other place, of workable thickness and in good condition, with an average breast above water level of from 200 to 400 feet. If only 18 inches of proper ore can be got from all five beds, along the whole $10\frac{1}{2}$ miles, there exists practically 925,000 cubic yards of the ore above water level. If the average thicknesses mined at Frankstown extend to Tyrone city, then there exists in the four miles of mountain side along the Pennsylvania Railway alone, and above water level alone, 42 to 64 inches $\times 7,040 \times 100 = 2,464,000$ to 3,731,200, = say three millions of cubic yards of ore.*

It is not to be expected that all the beds can be mined at any one place; but a million of tons of good merchantable soft fossil ore to be won from the southwest division of the Lyon, Shorb & Co.'s lands, *above water level* cannot be an unreasonable estimate.

This ore is greatly esteemed and extensively used by all the furnaces of Pennsylvania which can get it. as an enriching flux for leaner iron-stones, and as a fusible mixture for refractory highgrade magnetites. At Frankstown and elsewhere it has furnished the greater part of the burden; and at other furnaces it is mixed in large proportions with brown hematites. It always holds lime in the condition of undissolved fossil shells, and works kindly with the sandy rock fossil (*a*) of the same (Upper Silurian) formation.

NOTE. March 4, 1874. Mr. Stewart has just made the important discovery, by running-in horisontally a monkey-drift, west of Tyrone Station, that four layers of soft fossil ore occur there in a space of seven feet, measuring respectively 18, 10, 5 and 2 inches. This affords nearly the normal quantity of 40 inches, and more than the quantity required for profitable exploitation. It is an especially important trial work, inasmuch as it casts an encouraging light on the untested and hitherto despised range of outcrop east of Tyrone. J. P. L.

* Mr. Rogers' formula of 50,000 tons of ore from each running mile of outcrop was based upon his then assumed maximum depth of no more than 30 yards for the soft ore in a stratum 18 inches thick, two tons of ore going to a cubic yard.